CAL LAB C21

BARBER COLMAN COMPANY

1252 / IN 27-4

DUAL OUTPUT PLASTIC EXTRUDER
TEMPERATURE CONTROLLERS
MODELS 522H, 523H, 524H, 522J, 523J,
524J, 522K, 523K, and 524K

INSTRUCTION MANUAL

The complete Instruction Manual for this Controller consists of the following pieces of literature.

Number	Section	Name
1252 IN 27	1	Description, Specifications, and Operation
1252 IN 17	2	Installation & Wiring
F-14851	3	Main Board Circuits and Calibration (Includes Wiring and Replaceable Mechanical Parts)
F-15675	3	Digital Indicator Supplement
F-16198	4	Isolation Board
F-16199	5	Troubleshooting Main Board and Range Boards, Changing Ranges
F-16200	6	Circuit Description & Service Alarm Boards
F-14852	7	Circuit Description & Service, Control Mode Boards
F-14859	8	Circuit Description & Service, Output Boards

IGNORE MATERIAL NOT APPLICABLE TO YOUR MODEL

LITHO IN U.S.A.

1.1 DESCRIPTION

1.1.1 General

This controller is designed for liquid cooled plastic extruders. Common GAIN, RESET, RATE, and CYCLE adjustments act on both the heating and cooling control to achieve a balanced output. The gain heating – cooling ratio is adjustable from 1:1 to 4:1. See Output Board Section to change to 1:1 to 1:4.

The Cooling Limit Adjustment is continuously adjustable to limit the percent on time between 5 and 100%.

The Series 520 is a modular controller designed to accept the output of a standard Barber-Colman thermocouple, resistance bulb, radiation pyrometer, or other millivolt source. Process variables such as temperature or pressure may be monitored either by a Deviation Meter or by a Process Meter. With either of these meters a 1-5 Vdc output signal for remote metering of a process can be specified. The front panel digital setpoint has either three or four digits depending upon the range. The thumbwheel switches of the setpoint can repeat settings within a resolution of 1°. An analog setpoint dial is marked with the range specified.

The plug-in design of this modular controller reduces down time by allowing quick replacement of either the controller or one of its modules.

Three control modes are available; namely, Proportional, Proportional plus Integral (automatic reset), and Proportional plus Integral plus Derivative (rate). A controller with the Proportional mode only has gain and manual reset adjusted by the front panel GAIN and RESET controls, respectively. Manual reset action is applied to the output of the controller to prevent offset (droop). Manual reset action is satisfactory when load changes are rare. A controller with the Proportional plus Integral mode has the gain and Integral actions adjusted by the front panel GAIN and RESET controls, respectively. Integral action of the controller prevents offset in operation where severe and frequent load changes occur. Reset Windup Inhibition is included with this control mode to control overshoot by inhibiting reset action during warmup time. Reset Windup Inhibition is particularly desirable in batch processes where large step increases or decreases are likely to occur.

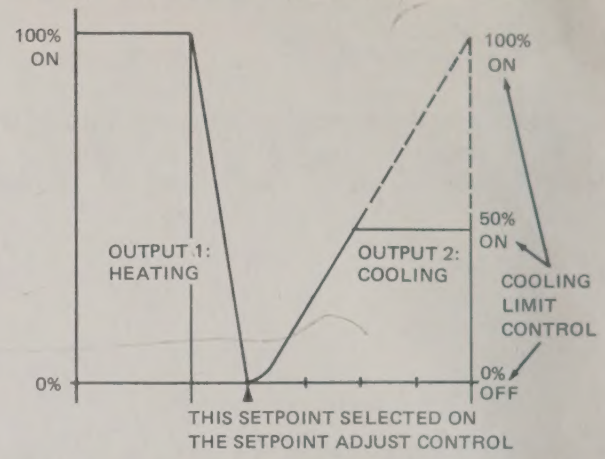
A controller with the Proportional plus Integral plus Derivative mode has Derivative action continuously adjustable by the RATE control from 0 to 3 minutes. Derivative action is available for processes where sudden upsets, appreciable transfer lag, or a small to moderate amount of dead time is present. Derivative action corrects the controller output proportional to the speed of change of a deviation.

1.1.2 Output 1

Solid State Switching Output controllers have outputs capable of 20 Amperes Inrush and 1 Ampere Continuous. Any voltage up to 240 Vac can be switched. Electromechanical contactors up to 100A or the Barber-Colman Series CB 11 and CB 13 Solid State Contactors up to 45 A and 37A, respectively, 480 Vac, can be switched. These models have a cycle time rate which can be adjusted from 10 to 30 seconds by means of the front panel CYCLE control.

1.1.3 Output 2

The cooling output has a special shaping network for smooth transition of control from one output to the other. Overlap of heating and cooling outputs is nominally zero.



This drawing shows a 4:1 heating-cooling gain ratio with the Cooling Limit Control set at 50%.

Figure 1-1. Relation of Outputs

1.2 SPECIFICATIONS

Input Signal A thermocouple span of 10 mVdc or greater. Thermocouple inputs have cold junction compensation. Total resistance of thermocouple and leadwire may be up to 200 ohms. A source resistance up to 1000 ohms may be accepted with less than ±1.5% calibration shift.

The input signal from an RTD (resistance temperature detector) is on 2-wire from a nominal resistance ranging from 100 to 1000 ohms, with a minimum span of 10% of the nominal resistance. For standard ranges, from a 100 ohm at 0°C platinum element with a temperature coefficient of .00391 ohm/ohm/°C.

Current Spans from 1 to 50 mAdc. 100mV drop.

Millivolt Spans from 10 to 100mVdc. Input resistance greater than one megohm.

Spans above .1 Vdc: .1 to 1 Vdc, 5kΩ input impedance; 1 to 10 Vdc, 50kΩ input impedance.

Radiation Pyrometer Spans from 14 to 100mVdc, with an emissivity ratio adjustment from .7 to 1. Up to 20k ohms input resistance.

Thermocouple Break Protection Upscale (standard) or downscale break protection.

Input Reference Input may be referenced to ground or floating.

Setpoint Temperature Digital Setpoint selectable on a three or four digit register by adjusting thumbwheel switches. Settings can be repeated exactly. Minimum digital span: 399 digits, Analog setpoint selectable on a 5-inch scale.

Readouts

Deviation Meter: deviation of process signal from setpoint indicated by meter calibrated either ±30, 50, 100, or 200 dependent on instrument span.

Analog Process Meter: process signal indicated over full span.

Digital Process Meter: process signal indicated in bright red 0.25 inch high numerals with Light Emitting Diodes (LED). Any positive range listed can be displayed.

Output Control Forms Current Outputs: 2-12mAdc into 0-1500 ohms and 4-20mAdc into 0-750 ohms. Short circuit protected and isolated, either terminal may be grounded. Solid State Switching Output: (both ON-OFF and Time Proportioning): 1A continuous, 20A inrush, 30mA minimum. Any voltage from 24Vac to 240Vac can be switched, but the voltage switched must be the same phase and have the same common line as the instrument power supply. Typical On-Off differential is 0.125% of span.

Cycle Time Acts on both outputs. Cycle time is adjustable from 10 to 30 seconds (nominal) by the CYCLE control. By removing one component cycle time can be changed to adjust from 3 to 10 seconds (nominal) for optimum control of a solid state contactor.

Separation of Output 1 and Output 2 Nominally zero.

Cooling Limit Continuously adjustable from 5 to 100% on time.

Gain Ratio Adjustment on Output Board Heat to Cool ratio is continuously adjustable from 1:1 to 4:1. A ratio from 1:1 to 1:4 can be obtained by moving a resistor.

Alarms Alarm trip point is set by the ALARM control. Alarm can be set to trip from either an increasing or a decreasing signal as follows:

Deviation: 0 to ±25% of span about setpoint.

Deviation Band Alarm: From + and -1.5% up to + and -25% of span. 50% maximum bandwidth.

Process: 0 to 100% of span.

Alarm Relay Contact Rating 2A at 120 Vac, resistive.

Gain (Proportional Band) For instruments with Proportional Action only, the GAIN control is adjustable from 10 to 100. For instruments with Proportional plus Integral action, the GAIN control is adjustable from 1 to 100. At a setting of 1, the proportional bandwidth is 100% of span; at 10, 10% of span; and at 100, 1% of span. Derivative (Rate) Action does not affect gain or proportional band.

Manual Reset Action Continuously adjustable by RESET control from 0 to 100% output at zero deviation (null).

Integral (Automatic Reset) Action Continuously adjustable by RESET control from 0.06 to 6 repeats per minute. When RESET control is fully CCW, integral action is turned off.

Reset Windup Inhibition Inhibition circuit reduces reset term to zero when the Demand Signal reaches maximum positive limit of proportional band.

Derivative (Rate) Action Continuously adjustable by RATE control from 0 to 3 minutes.

Reference Accuracy ±0.5% of span.

Reference Operating Conditions

Ambient Temperature: 75°F.

Operating Power Supply: 120 or 240 Vac, ±1%, 50 or 60 Hz.

Source Resistance (TC ranges only): 10 ohms.

Rated Accuracy ±(1% of span plus 0.5% of suppression).

Rated Operating Conditions

Ambient Temperature: 40°F to 130°F.

Operating Power Supply: 120 or 240 Vac, ±10%, at 60 Hz, or 110 or 220 Vac, ±10%, at 50 Hz, by terminal selection.

Humidity: 0-70% RH.

Position (tilt): any position.

Common Mode Rejection: 140 decibel

Maximum Common Mode Voltage: 120 Vac rms.

Series Mode Rejection: 70 decibel.

Maximum Series Mode Voltage: 5X span.

Source Resistance (TC ranges only): 0-200 ohms.

Extreme Operating Conditions

Ambient Temperature: 0°F to 150°F.

Operating Power Supply: Nominal Line Voltage ±15%.

Humidity: 0-90% RH.

Storing Temperature −40°F to +150°F.

Frequency Response Direct current to 0.7 Hz in the proportional action only controllers. Depends on setting of RESET control in Proportional Plus Integral Action Controllers.

Line Voltage Stability 10% change in line voltage will not shift control by more than 0.1% of span.

Temperature Stability

4 microvolts per °F, maximum.
2 microvolts per °F, typical.

Sensitivity 0.00075% of span for 100% change in output.

Isolation Fully Isolated

Isolated Remote Setpoint Voltage (Optional) 1-5Vdc. Source should be free of transients and have an impedance less than 200 ohms. For operation of more than one controller from the same external source, a source resistance under 50 ohms is recommended. Input impedance is 1M ohms typical.

Isolated Trim Setpoint (Optional) Requires 1-5Vdc setpoint voltage from an external source. Source resistance up to 20 ohms. Trim control adjusts the instrument setpoint ±5% of span. Input impedance is 20k ohms.

Isolated Output Setpoint Voltage (Optional) 1-5Vdc proportional to instrument setpoint span. Short circuit has no effect on control action. Source resistance less than 10 ohms.
Maximum total output current of Process Signal Output option plus Output Setpoint Voltage option is 10mAdc.

Isolated Process Signal (Optional): 1-5Vdc on rear panel terminals. External short circuit has no effect on control action. Source resistance less than 10 ohms. Maximum total output current of Process Signal Output option plus Output Setpoint Voltage option is 10mAdc.

Power Consumption 7 VA.

Shipping Weight 4 pounds (no housing).

1.3 OPERATION

1.3.1 Front Panel Controls and Indicators

SETPOINT ADJUST Control Control for selecting the nominal setpoint temperature. Since the separation of OUTPUT 1 and OUTPUT 2 is nominally zero, this setpoint adjustment is for both outputs.

Amber Lamp Located on the left side of the upper front panel. Glows when the solid state switch for OUTPUT 1 is on.

White Lamp Located in the center of the upper front panel. Glows when the solid state switch for OUTPUT 2 is on.

Red Alarm Lamp (Optional Auxiliary Alarm) Located on right side of upper front panel. Steady glow indicates an alarm.

ALARM Control on Main Board (Optional Auxiliary Alarm Adjustment) Potentiometer for selecting alarm trip point.

Deviation Alarm: 0 to 25% of span about setpoint.

Deviation Band Alarm: From + and -1.5% up to + and -25% (fully CW) of span. 50% maximum bandwidth.

Process Alarm: 0-100% (fully CW) of span.

GAIN Control on the Main Board Single turn potentiometer and switch for selecting gains of 10 (fully CCW) to 100 (fully CW) for Proportional Action Only Controllers; and, from 1 (fully CCW) to 100 (fully CW) for Proportional plus Integral Action Controllers. At a setting of 1, the proportional bandwidth is 100% of span; at 10, 10% of span; and, at 100, 1% of span. Derivative (Rate) Action does not affect the gain (proportional band). This control acts on both outputs.

Manual RESET Potentiometer on Control Mode Board (Models 522H, 522J, and 522K) Single turn potentiometer for selecting 0 (fully CCW) to 100% (fully CW) output at null with the GAIN pot set at 10 (fully CCW). Requires narrower adjustment range for higher gains. This control acts on both outputs.

Integral RESET Potentiometer on Control Mode Board (Models 523H, 523J, 523K, 524H, 524J, and 524K) Single turn potentiometer for selecting .06 to 6 (fully CW) repeats per minute. When fully CCW, integral action is turned off. This control acts on both outputs.

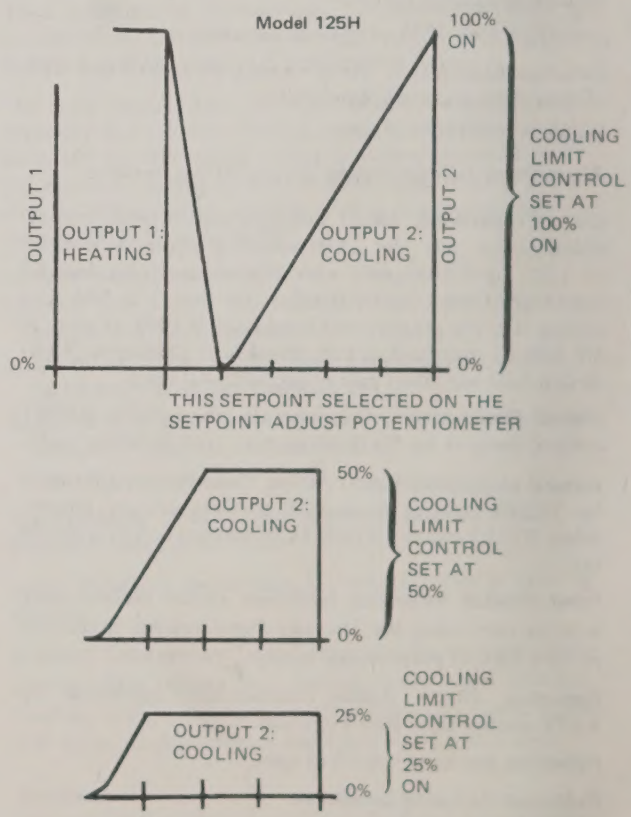
Derivative RATE Control, on Control Mode Board (Models 524H, 524J and 524K) Single turn potentiometer for selecting a Derivative Action time from 0 (fully CCW) to 3 (fully CW) minutes.

Cooling Limit Potentiometer (located in the hole above the word SPREAD) Continuously adjustable to limit the percent on time between 5 (CCW) and 100% (CW). This prevents excess cooling which can damage the barrel of an extruder.

CYCLE Potentiometer on Output Board Single turn potentiometer for selecting a cycle time from 10 (fully CW) to 30 (fully CCW) seconds. This control acts on both outputs of Models 522H, 523H, and 524H; but, only on OUTPUT 2 of Models 522J, 523J, 524J, 522K, 523K and 524K.

LOCAL–REMOTE Switch (Setpoint Option 5) When Setpoint Option 5 is specified the red alarm lamp is replaced by the two positon LOCAL–REMOTE switch. In the REMOTE position (down) the setpoint is an external setpoint on rear panel terminals 4 and 5. In the LOCAL position (up) the setpoint is determined by the setpoint control below the switch.

TRIM Control (Setpoint Option 8) Single turn potentiometer for decreasing a remote setpoint voltage -5% of span (fully CCW) to increasing the remote setpoint voltage +5% of span (fully CW). TRIM control is marked -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, and 5 in Percent of Span. When Setpoint Option 8 is specified the TRIM control replaces the front panel SETPOINT ADJUST control.



1.3.2 Preliminary Adjustments

It may be necessary to operate the process equipment to make preliminary adjustments on it and also, for example,

to dry out furnace liner material. During any preliminary operation, turn the RESET control fully CCW to its off position. Turn the GAIN control fully CCW to minimum gain (maximum proportional band). Now adjust the SETPOINT ADJUST control.

Always make a permanent record of any final settings for a specific process so that if the controls are changed for any reason, the original settings can be duplicated. Upsets can be simulated by turning the Setpoint Adjust control to different settings with the degree of upset desired proportional to the change in setting. Allow enough time, when making adjustments, for the system to stabilize. Remember that optimum controller adjustments are those that produce satisfactory results in a stable system. Optimum adjustments are not necessarily the finest and most sensitive settings that can be obtained.

1.3.3 Models 522H, 522J and 522K Controllers With Proportional Action Only

The output of these controllers is a proportional output correction signal for returning the process variable to the setpoint selected on the SETPOINT ADJUST control. The amount of amplification is selected by the operator on the GAIN control. Set the GAIN control low enough to produce as close as possible to a straight line (Process Temperature versus Time), but no lower. If there is overshoot of the setpoint for OUTPUT 1 or more than minimum recovery time from a step change in the process variable reduce the gain to obtain minimum recovery time. With proportional action only there may be an offset (droop) of the measured variable from the setpoint selected on the SETPOINT ADJUST control, unless the power requirement is 50% (balanced).

The process should be stabilized (zero deviation) at the selected setpoint.

1. If offset is below zero deviation, turn the RESET control CW one mark and allow time for the process to stabilize. Continue CW rotation in this manner until the process stabilizes.

2. If offset is above zero deviation, turn the RESET control CCW one mark and allow time for the process to stabilize. Continue CCW rotation in this manner until the process stabilizes.

1.3.4 Models 523H, 523J, and 523K Controllers With Proportional Plus Integral Action

The following procedure gives initial settings that represent a compromise between close control of minor process upsets and good recovery from large upsets. Allow plenty of time for the process to stabilize after each adjustment. Proceed as follows:

1. Turn the GAIN control to midpoint.

2. Turn the RESET control fully CCW to off.

3. Set the SETPOINT ADJUST control to the operating setpoint.

4. Allow plenty of time for the controlled variable to stabilize at the operating setpoint.

5. For either of the two conditions (A or B) that follow, after each change in setting of the GAIN control, a simulated process upset should be caused by changing the SETPOINT ADJUST control about 5% (this is 50°F for a scale of 1000°F) of scale range. Such a simulated process upset will show any tendency to cycle. Changes in the setting of the SETPOINT ADJUST control should be made up and down alternately to remain near the operating setpoint selected in step 3.

   A. If the process variable is stable, turn the GAIN control CW in steps of one division until instability is reached. After the process becomes unstable, turn the GAIN control CCW one division.

   B. If the process variable is unstable, turn the GAIN control CCW until the process variable becomes stable.

6. After the completion of step 5, allow time for the process to settle down at the setpoint selected in step 3. Then turn the RESET Control to the mid-point position, and observe the behavior of the process.

   A. Wait from 2 to 5 minutes. If the process is stable, increase the RESET Control CW in small increments until the process oscillates. Next, reduce the setting by going CCW in small increments until the oscillations cease.

   B. If the midpoint setting is too fast for the process, cycling will occur. If cycling occurs, turn the RESET control one division CCW. Wait for the process to settle down. If it does not again turn the RESET control one division CCW. Continue this procedure until the process settles down.

7. Introduce a step change of 5% to 10%. For best results, the step response should be observed on a recorder. With a recording, very fine observations can be made to obtain closer to optimum settings. Taking a recording is almost mandatory for very critical processes, where both overshoots and settling times must be minimized. Fortunately, the majority of processes are not so critical and satisfactory results may be obtained without special equipment simply by observing the deviation. Monitoring the output on the current output models is also very helpful in searching for a tendency to cycle, but usually is not necessary.

   A. If more overshoot occurs than can be tolerated, decrease the setting of the GAIN control CCW in steps of about one division. If more than two steps are required, it may be preferable to turn the RESET control CCW to a lower setting, rather than to continue on to an unusually wide proportional band (i.e., low GAIN control setting).

   B. If there is overshoot, the time required to reach the new equilibrium may be excessive – at any rate, it can be reduced by increasing the GAIN control setting CW until a single, small overshoot occurs in response to a step change. Such a setting is usually preferred, as settling time is minimal. If more than three steps are required to obtain an overshoot, it may be preferable to advance the RESET control CW in small increments, then

widen the proportional band (i.e., decrease the GAIN control setting CCW) to achieve stability.

1.3.5 Models 524H, 524J, and 524K Controllers With Proportional Plus Integral Plus Derivative Action

Derivative action occurs only when the input signal is changing. Should too much Derivative action be added to a process, it will cause instability similar to the instability caused by too much Integral action or too much Gain action. Too little Derivative action will not provide enough correction for error. With the correct amount of Derivative time applied, large upsets tend to be anticipated. In general, a slow responding process requires very little if any Derivative time.

Proceed as follows:

1. First perform the procedure in paragraph 1.3.4.

2. Set the RATE Control to mid-position.

3. Introduce a step function change by increasing or decreasing the setpoint approximately 5% of span. The process may either oscillate or stabilize at the new control point.

   A. If the process remains stable, increase the rate setting slightly CW. Make another setpoint change by returning to the control point. Repeat the procedure until a rate setting is found which will cause oscillations. When the setting is found, reduce the setting CCW to the point where oscillations will not occur with a step change.

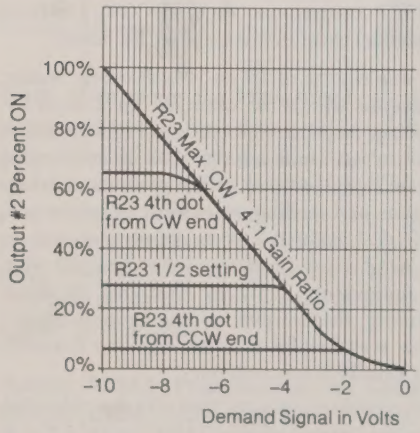
   B. If the process went into oscillation with a setpoint change, reduce the rate setting CCW. Check the new setting by making another step change. Repeat until a setting is found where the process will not oscillate with a setpoint change.

1.3.6 Cycle Time (Models 522H, 523H, and 524H)

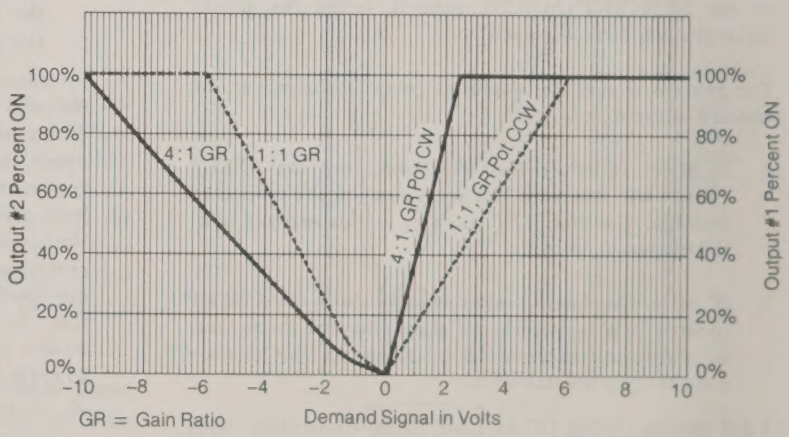
The CYCLE control will change the cycle time from 10 (at CW) to 30 (at CCW) seconds per cycle. The faster cycle rates of the order of 6 seconds per cycle provide better control of loads with fast response times and little time lag. However, a relatively faster cycle time causes added wear on an external contactor. By removing a capacitor on the output board, cycle time can be changed to adjust from 3 to 10 seconds (nominal) for optimum control of a solid state contactor. Refer to the Calibration Section for location of this capacitor.

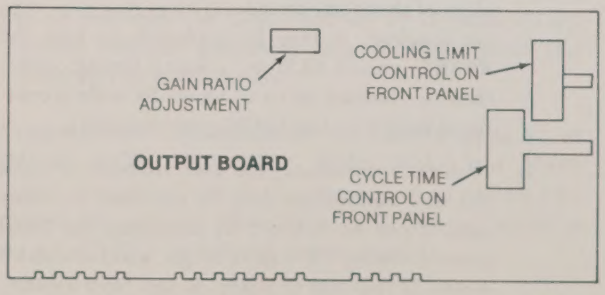
This control acts on both outputs of Models 522H, 523H, and 524H; but, only on OUTPUT 2 of Models 522J, 523J, 524J, 522K, 523K and 524K.

Effect of Varying Front Panel Cooling Limit Control



Effect of Varying Gain Ratio Potentiometer on Board





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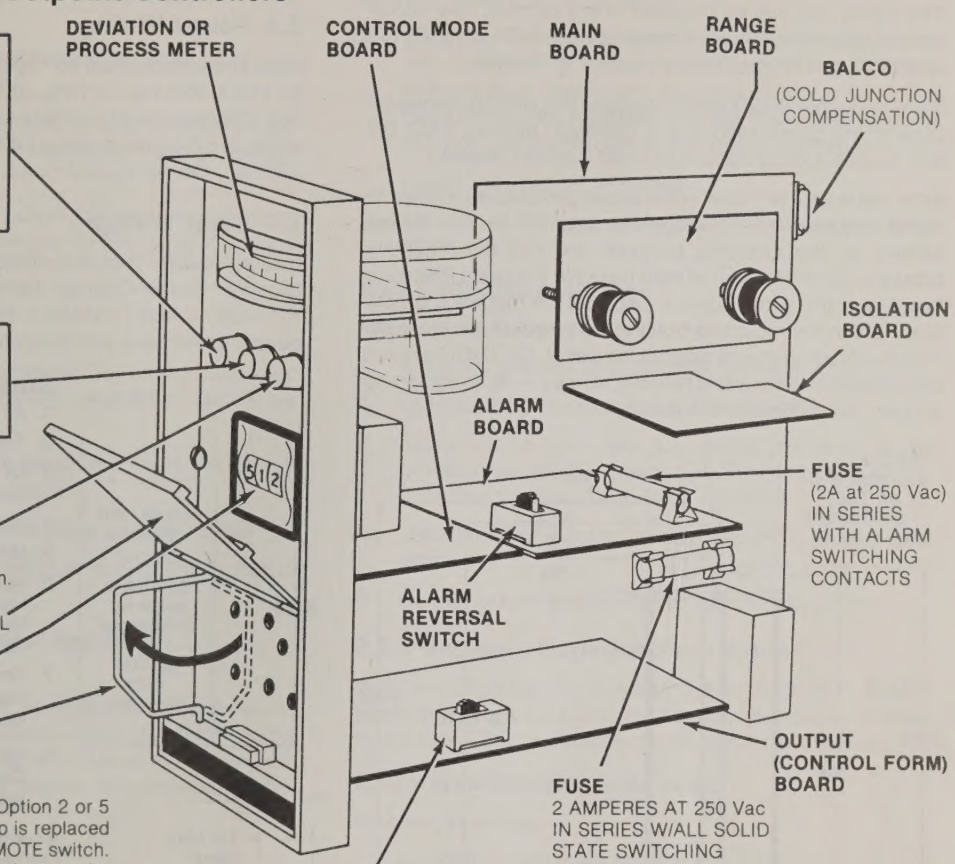
LITHO IN U.S.A.

SERIES 520 — Models 521, 522, 523 and 524
Analog and Digital Setpoint Controllers


DEVIATION OR PROCESS METER
CONTROL MODE BOARD
MAIN BOARD
RANGE BOARD
BALCO (COLD JUNCTION COMPENSATION)
ISOLATION BOARD
ALARM BOARD
FUSE (2A at 250 Vac) IN SERIES WITH ALARM SWITCHING CONTACTS
ALARM REVERSAL SWITCH
OUTPUT (CONTROL FORM) BOARD
FUSE 2 AMPERES AT 250 Vac IN SERIES W/ALL SOLID STATE SWITCHING OUTPUTS
20 AMPERES AT 250 Vac IN SERIES WITH LIMITROL CONTACTS
OUTPUT 2 REVERSING SWITCH FOR ON-OFF OUTPUTS ONLY

AMBER LAMP ON CONTROLLERS
Either glows to indicate Output 1's solid state switching is on,
or
Steady glow if Output 1 is a current output, to indicate power is on to the instrument.

RED LAMP ON LIMITROL
Steady glow indicates selected setpoint is exceeded.

WHITE LAMP ON DUAL OUTPUT CONTROLLERS
Glows to indicate Output 2's solid state switching is on.

RESET PUSHBUTTON ON LIMITROL
Press to reset Limitrol after excess temperature drops below setpoint.

RED ALARM LAMP
Steady glow indicates an alarm.

DOOR SWUNG UP TO REVEAL CONTROL ADJUSTMENTS

DIGITAL SETPOINT

HANDLE — Pull out to remove controller from its housing.

NOTE: When either Setpoint Option 2 or 5 is specified, the red alarm lamp is replaced by the two position LOCAL-REMOTE switch. In the REMOTE position (down) the setpoint is an external setpoint on rear panel terminals 4 and 5. In the LOCAL position (up) the setpoint is determined by the setpoint control below the switch.

When Setpoint Option 7 is specified, the Setpoint is omitted.

When Setpoint Option 8 is specified, the Setpoint is replaced by a Trim Control which can be set to adjust the setpoint signal from a Master Controller ±5% of span.

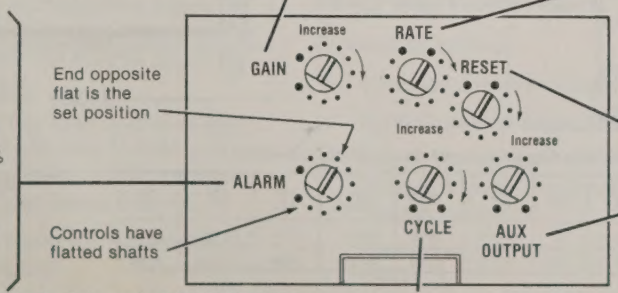
WARNING
FUSE SIZE MUST NOT BE EXCEEDED. COPPER FOIL ON MAIN BOARD WILL BE DESTROYED AT HIGHER CURRENTS.

Figure 2-1. Parts Description

GAIN
Proportional Action Only: 10 to 100 (P.B.: 10 to 1%)
Proportional plus Integral Action: 1 to 100 (P.B.: 100 to 1%)
Derivative (Rate) Action does not affect the gain or P.B.

RATE (DERIVATIVE TIME)
0 to 3 Minutes

MANUAL RESET	AUTOMATIC RESET
0 to 100% output at null	.06 to 6 repeats per minute. CCW click off.



DEVIATION ALARM
Up to ±25% of span from setpoint

DEVIATION BAND ALARM
Adjustable from 3% to 50% of span centered about setpoint

PROCESS ALARM
0-100% of span

End opposite flat is the set position

Controls have flatted shafts

Determines separation of Output 1 and Output 2 on Dual Output Controllers from −25% to +25% of span from the setpoint selected on the Output 1 setpoint.

Output 2 is switch reversible. Only on models 522E, 523E, 524E, 522F, 523F, 524F, 522G, 523G, and 524G.

COOLING LIMIT ADJUSTMENT (located in the hole marked AUX OUTPUT). Continuously adjustable to limit the percent ON time between 5 (CCW) and 100 (CW). This prevents excess cooling. Only on models 522H, 523H, 524H, 522J, 523J, 524J, 522K, 523K, and 524K.

6 to 60 sec. B, E

10 to 30 sec. H, J, K

Figure 2-2. Functions of Internal Front Panel Controls

2.1 After Unpacking

Check the contents of the shipping container against the packing slip. If the equipment is damaged in transit, report the extent of the damage to the carrier immediately.

2.2 Mounting

The Series 520 can be mounted in any position. The instrument is rated for an ambient temperature from 5° to 55°C (40° to 130°F), and relative humidity from 0 to 70% RH.

Refer to Figure 2-3 for Panel Cutout and Mounting Dimensions. Dimensions guaranteed only if Certified Drawing, 1252 DR 4-1, is used. Consult factory to order Certified Drawing.

After the cutout is made in the panel, proceed as follows to install one instrument. Completely unscrew the two driving screws for the mounting brackets and pull the mounting brackets completely out of their tracks in the case. Place the housing in the panel cut-out. Replace the mounting brackets. Tighten the mounting bracket screws until the brackets hold the housing snugly against the panel. CAUTION: Do not over-tighten the mounting bracket screws — over-tightening screws could damage the panel.

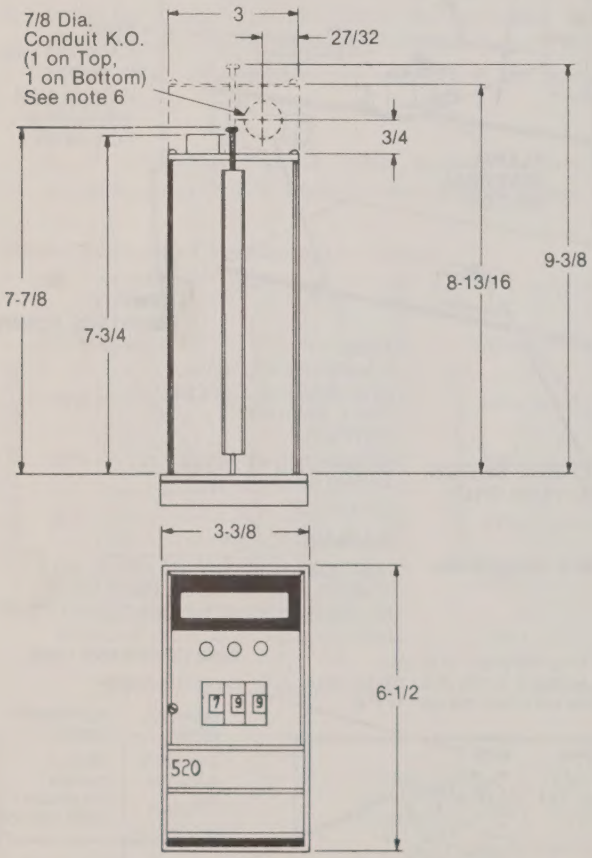
The captive screw on the left side of the panel in the middle is the fastener for the instrument. After the housing is mounted in the panel, push the controller firmly into its slot until the screw touches the threaded hole in back of it. Do not push instrument further but instead turn screw clockwise until instrument is pulled fully into its housing.

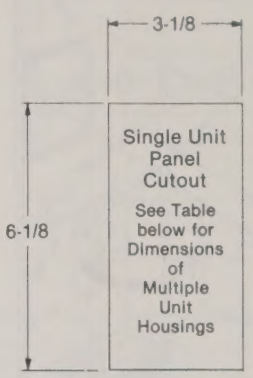
2.3 Power Wiring

Input line voltage must be 120 or 240 Vac, ± 10%, at 60 Hz; or, 110 or 220 Vac, ± 10%, at 50 Hz; by rear terminal selection. Connect the line voltage to the terminal marked L2 and either the terminal marked 240V L1 or the terminal marked 120V L1. Connect panel ground to the GROUND terminal.

2.4 Input Wiring

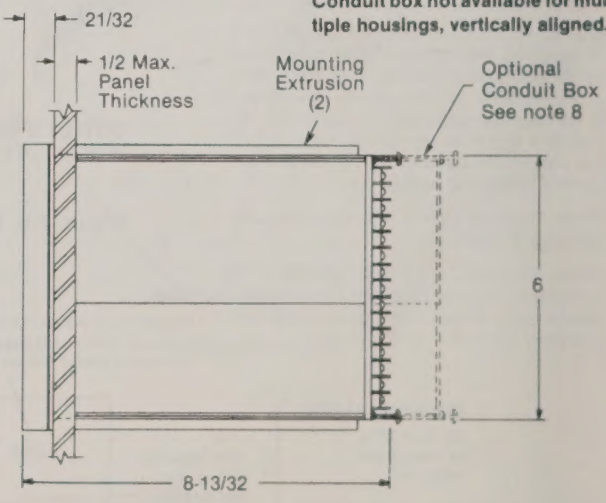
Install a quality Barber-Colman thermocouple for your application. Barber-Colman thermocouple catalogs, such as 1111/DB 12 and 1130/DB 1, list a complete line of thermocouple assemblies and thermocouple extension leadwire.





NOTES:

1. All dimensions in inches.
2. Tolerance all dimensions ± 1/16.
3. Dimensions guaranteed only if this print is certified. Consult factory.
4. Min. horz. spacing centers 3-7/16.
5. Min. vert. spacing centers 6-9/16.
6. Appleton No. 92T050 two piece steel conduit connector or equivalent must be used for conduit connections.
7. For mounting in a 19" relay rack 7" high the max. no. of units will be 1 row of 5.
8. Conduit box fitted to case at factory. **Conduit box not available for multiple housings, vertically aligned.**



Number of Units Aligned Horizontally and Width in Inches

No. of Units Vertically Aligned	Height of Cutout in Inches	1	2	3	4	5	6	7	8	9
1	6-1/8	3-1/8	6-9/16	10	13-7/16	16-7/8	20-5/16	23-3/4	27-3/16	30-5/8
2	12-11/16	3-1/8	6-9/16	10	13-7/16	16-7/8	20-5/16	23-3/4	27-3/16	30-5/8

All Dimensions in Inches

Total Number of Units = Units Horizontal × Units Vertical

Examples:

1. Single Panelmount cutout is 3-1/8" wide by 6-1/8" high.
2. An array of 9 wide by 2 high, cutout is 30-5/8" wide by 12-11/16" high.
3. For one row of 5 housings, cutout is 16-7/8" wide by 6-1/8" high.

Note: Standard Relay Rack Panel Cutouts are made at the factory; and, the housings specified are shipped fastened to the panel. **See 1252/DB 3 for more information on Multiple Unit Housings.**

Figure 2-3. Mounting Dimensions

The SIGNAL input terminals are marked TC + and TC – and are for any input.

Thermocouples should never be wired using ordinary copper wire. Use only thermocouple extension leadwire.

Observe the correct thermocouple and thermocouple extension wire polarity. The NEGATIVE (–) wire is usually coded RED.

Do not place power wiring and thermocouple wiring in the same conduit or wiring trough.

If shielded thermocouple leads are used, shields should be insulated electrically and terminated at one location, preferably the instrument chassis.

For RTD sensors there is no polarity to observe. For three wire RTD sensors, connect the two WHITE wires together.

2.5 Alarms

2.5.1 General

These alarms are not recommended for safety purposes. For safety purposes the Models 521L and 521T Limitrols are recommended.

Alarm boards in the Series 520 are shipped from the factory with the following wiring conditions:

1. Alarm light is on when alarm relay is de-energized.
2. Normally open alarm contact is connected to instrument alarm terminals.

2.5.2 ALARM Potentiometer and Alarm Reversal Switch

Either a Process, a Deviation, or a Deviation Band Alarm may have been specified. The alarm action is determined by the front panel ALARM pot and by a slideswitch located on the Alarm Board. Figure 2-1 shows the location of the switch.

Set the switch as follows.

Process Alarm: pull out to alarm* on decreasing signal, push in to alarm* on increasing signal.

Deviation Alarm: pull out to alarm* on decreasing signal, push in to alarm* on increasing signal.

Deviation Band Alarm: push in to alarm* inside the bandwidth, pull out to alarm* outside the bandwidth,

*"to alarm" means that terminals 6 and 7 open.

Next, set the ALARM potentiometer.

The Process Alarm can be set to trip anywhere within the span of the instrument (0 to 100% of span) by means of the 20-turn ALARM potentiometer. Turn the ALARM pot clockwise to increase the alarm trip point.

The Deviation Alarm can be set to trip up to ±25% of span from setpoint by means of the single turn ALARM potentiometer. With the ALARM pot turned fully CCW the alarm will trip at a deviation of 25% of span below setpoint.

With the ALARM pot fully CW the alarm will trip at a deviation of 25% of span above the setpoint.

The Deviation Band Alarm can be set to trip from plus and minus 1.5% of span about setpoint to plus and minus 25% of span about setpoint. Total bandwidth is adjustable from 3% to 50% of span centered about setpoint. Rotating the single-turn ALARM pot clockwise (CW) widens the deviation band.

2.5.3 Setting a Deviation Alarm Trip Point

2.5.3.1 With Millivolt Source Input

Proceed as follows.

1. Disconnect any input or output.
2. Turn power on to the Series 520.
3. Connect a d-c millivolt source (B-C Portable Potentiometer output) to the SIGNAL input terminals. Increase the millivolt input signal until it is above (below for a low deviation alarm) midscale and the difference between the signal and midscale is the desired deviation.
4. Adjust the setpoint to midscale.
5. Turn the ALARM potentiometer until the red alarm lamp lights.

2.5.3.2 With Process Input

Proceed as follows.

1. Allow the process to stabilize at the desired setpoint.
2. Quickly perform steps 3, 4 and 5 that follow.
3. Adjust the setpoint until it is below (above for a low deviation alarm) the desired setpoint mentioned in step 1, by the amount of the alarm deviation.
4. Turn the ALARM potentiometer until the red alarm lamp lights.
5. Quickly return setpoint to the value it had in step 1.

2.5.4 Setting a Deviation Band Alarm

With the Deviation Band Alarm option, when the ALARM potentiometer is fully CW, the bandwidth is 50% of span. When fully CCW, the bandwidth is about 3% of span.

2.5.4.1 With Millivolt Source Input

Proceed as follows.

1. Disconnect any input or output.
2. Turn power on to the Series 520.
3. Connect a d-c millivolt source (B-C Portable Potentiometer output) to the SIGNAL input terminals. Increase the millivolt input signal until it is above (or below) midscale and the difference between the signal and midscale is half the desired bandwidth.
4. Adjust the setpoint to midscale.
5. Turn ALARM potentiometer until red lamp lights.

2.5.4.2 With Process Input

Proceed as follows.

1. Allow the process to stabilize at the desired setpoint.
2. Quickly perform steps 3, 4 and 5 that follow.
3. Adjust the setpoint until it is above (or below) the desired setpoint mentioned in step 1, by the amount of half the bandwidth.
4. Turn the ALARM potentiometer until the red alarm lamp lights.
5. Quickly return setpoint to the value it had in step 1.

2.5.5 Setting a Process Alarm Trip Point

Proceed as follows.

1. Disconnect any input or output.
2. Turn power on to the Series 520.
3. Connect a d-c millivolt source to the SIGNAL input terminals. Adjust the millivolt input signal to the equivalent of the desired alarm temperature.
4. Turn the ALARM potentiometer until the red alarm lamp lights.

2.5.6 Re-connecting the Red Alarm Lamp to Indicate a Safe Condition

Do not make this wiring change for a safety related application. This wiring condition is suitable for such purposes as the following: indicating that temperature is normal, furnace or extruder is ready to operate, extruder barrel temperature is at required temperature, zone temperature on furnace or extruder is at required temperature.

To make this wiring change refer to Figure 2-4 and proceed as follows. A black lead from the red alarm lamp is connected to terminal D on the Alarm Board. Disconnect the black lead from terminal D and connect it to the adjacent terminal E.

2.5.7 Re-connecting the Normally Open Alarm to Normally Closed

Do not make this wiring change for a safety related application. This wiring condition is suitable for such purposes as the following: programming and sequencing.

To make this wiring change refer to Figure 2-4 and proceed as follows. A gray wire from the printed circuit board connector number 11 is connected to terminal B. Disconnect the gray wire from terminal B and connect it to terminal A.

2.6 Reversing the ON-OFF Output — Model 521A

— IMPORTANT —

INSTRUMENT MUST HAVE BEEN ORDERED WITH DOWNSCALE TCB (THERMOCOUPLE BREAK ACTION) IN ORDER TO MAKE THIS CHANGE.

The Model 521A is shipped with pin A connected to pin B by means of a jumper; and, with pin C connected to pin D by means of a jumper.

To reverse the ON-OFF output, make the jumper connections shown in Figure 2-5; that is, connect pin C to pin B, and connect pin A to pin D.

2.7 Changing Limitrol Output from High Limit to Low Limit — Models 521L and 521T

— IMPORTANT —

INSTRUMENT MUST HAVE BEEN ORDERED WITH DOWNSCALE TCB (THERMOCOUPLE BREAK ACTION) IN ORDER TO MAKE THIS CHANGE.

The Model 521L is shipped with pin A connected to pin B by means of a jumper; and, with pin C connected to pin D by means of a jumper. This is an "upscale" Limitrol.

To change to a "downscale" Limitrol make the jumper connections shown in Figure 2-5; that is, connect pin C to pin B, and connect pin A to pin D.

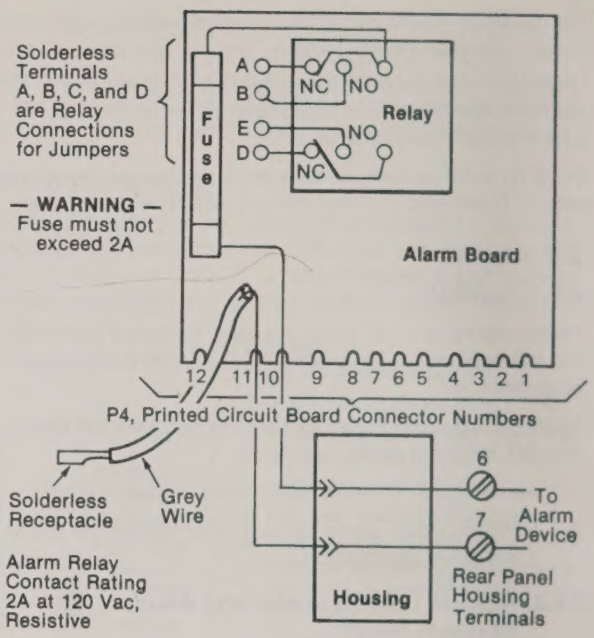


Figure 2-4. Alarm Wiring

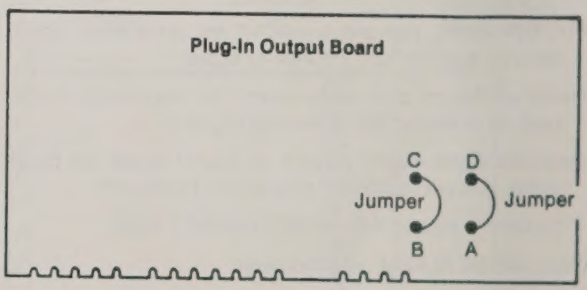
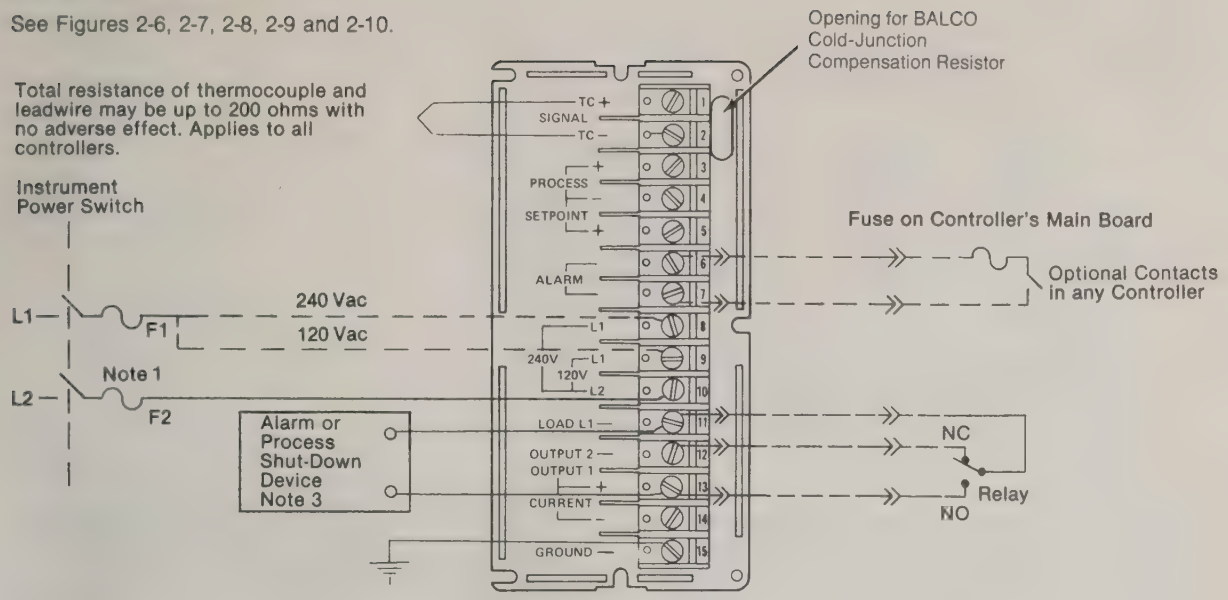


Figure 2-5. Jumpers

2.8 Output Wiring

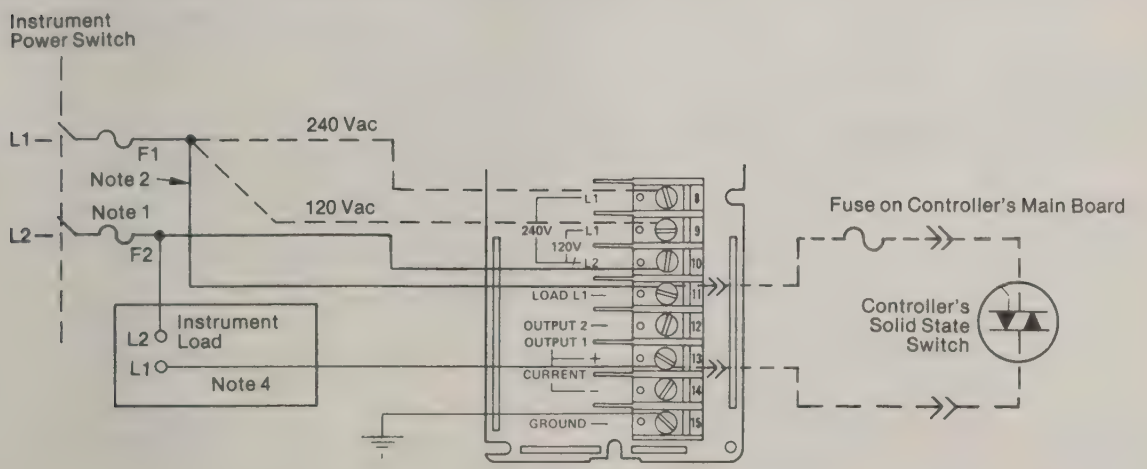
See Figures 2-6, 2-7, 2-8, 2-9 and 2-10.



Notes:

1. Instrument power switch and instrument fuses are included for illustrative purposes only. If the L2 line is a neutral or ground line, fuse F2 is not normally recommended. Consult local codes and appropriate wiring standards.
2. Limitrol Relay Contact Ratings: 5A at 120 or 240 Vac.
3. Power connections are made at the discretion of the installer.

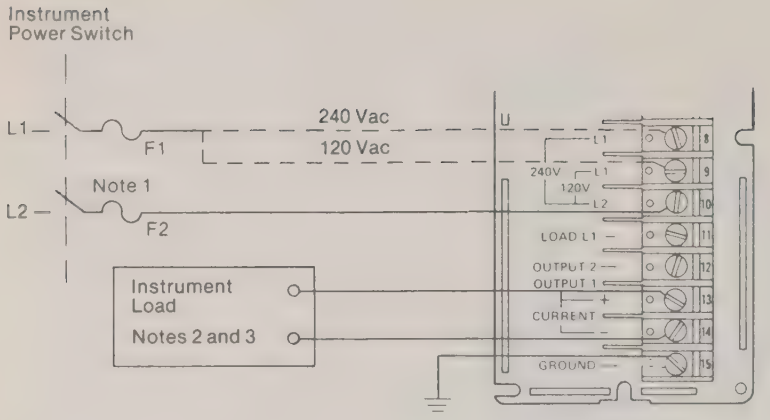
Figure 2-6. Output Wiring, Limitrol Models 521L and 521T



Notes:

1. Instrument power switch and instrument fuses are included for illustrative purposes only. If the L2 line is a neutral or ground line, fuse F2 is not normally recommended. Consult local codes and appropriate wiring standards.
2. Instrument load power, LOAD L1, may be obtained from a separate power source in phase with the instrument power supply. Instrument signal light will not operate unless instrument L2 and instrument load L2 are connected as shown. Instrument signal light will not operate if LOAD L1 is powered by a separate source of less than 100 Vac rms.
3. Instrument load may be either a contactor coil, a Barber-Colman SOLID STATE CONTACTOR, or heater.
4. Rating of Solid State Switching Output. (both ON-OFF and Time-Proportioning): 1A continuous, 10A inrush, 50mA minimum. Any voltage from 24 Vac to 240 Vac can be switched but the voltage switched must be the same phase and have the same common line as the instrument power supply.

Figure 2-7. Output Wiring, Single Solid State Switching Output Models 521A and 522B, 523B, 524B

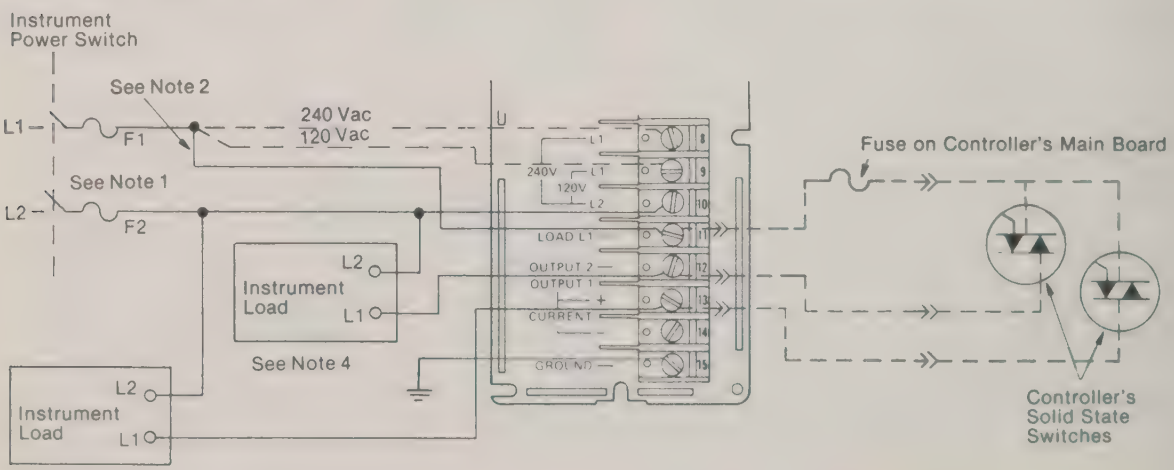


Notes:

1. Instrument power switch and instrument fuses are included for illustrative purposes only. If the L2 line is a neutral or ground line, fuse F2 is not normally recommended. Consult local codes and appropriate wiring standards.
2. The constant current outputs of these controllers are short circuit proof. Either plus or minus may be grounded or remain floating.
3. Either the 2-12mA or 4-20mA output will drive the Model 658 Current-to-Position Converter for positioning a Barber-Colman Motor Operator or a Current-to-Pneumatic Transducer.

   Either current output will drive Barber-Colman Power Controllers.
4. Current Output: either 2–12mA into 1.5k ohms or less; or 4–20mA into 750 ohms or less.

Figure 2-8. Output Wiring, Single Current Output Models, 522C, 523C, 524C and 522D, 523D, 524D 522P, 523P, 524P and 522Q, 523Q, 524Q



Notes

1. Instrument power switch and instrument fuses are included for illustrative purposes only. If the L2 line is a neutral or ground line, fuse F2 is not normally recommended. Consult local codes and appropriate wiring standards
2. Instrument load power, LOAD L1, may be obtained from a separate power source in phase with the instrument power supply. Instrument signal light will not operate unless instrument L2 and instrument load L2 are connected as shown. Instrument signal light will not operate if LOAD L1 is powered by a separate source of less than 100 Vac rms.
3. Instrument load may be either a contactor coil, a Barber-Colman SOLID STATE CONTACTOR, or heater
4. Rating of Solid State Switching Output: (both ON-OFF and Time-Proportioning): 1A continuous, 10A inrush, 50mA minimum. Any voltage from 24 Vac to 240 Vac can be switched but the voltage switched must be the same phase and have the same common line as the instrument power supply.

Figure 2-9. Output Wiring, Dual Solid State Switching Outputs. Models 522E, 523E, 524E and 522H, 523H, 524H

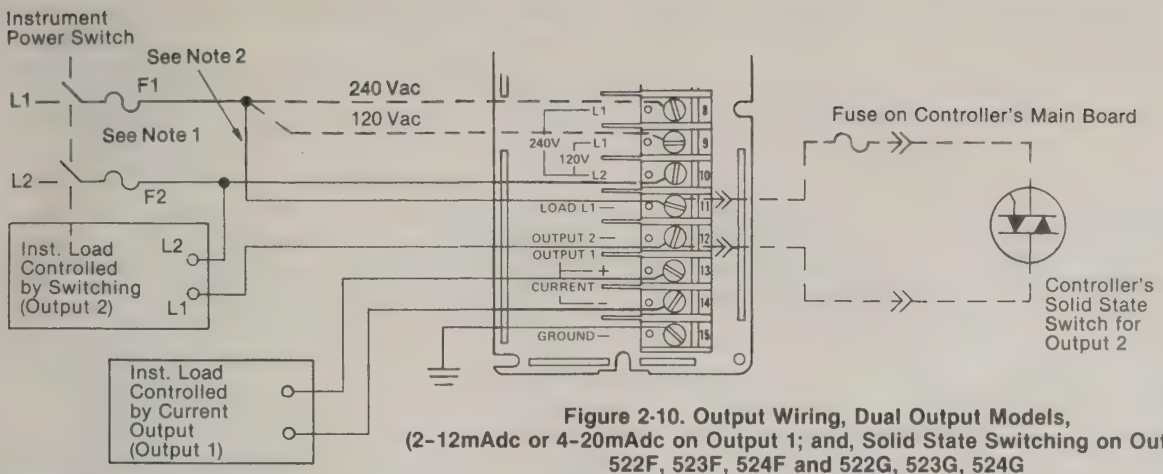


Figure 2-10. Output Wiring, Dual Output Models, (2-12mAdc or 4-20mAdc on Output 1; and, Solid State Switching on Output 2) 522F, 523F, 524F and 522G, 523G, 524G 522J, 523J, 524J and 522K, 523K, 524K

Notes:

1. Instrument power switch and instrument fuses are included for illustrative purposes only. If the L2 line is a neutral or ground line, fuse F2 is not normally recommended. Consult local codes and appropriate wiring standards.
2. OUTPUT 1: The constant current outputs of these controllers are short circuit proof. Either plus or minus may be grounded or remain floating.

   Either the 2–12mA or 4–20mA output will drive the Model 658 Current-to-Position Converter for positioning a Barber-Colman Motor Operator or a Current-to-Pneumatic Transducer.

   Either current output will drive Barber-Colman Power Controllers.

   Current Output: either 2–12mA into 1.5k ohms or less; or 4–20mA into 750 ohms or less.
3. OUTPUT 2: Instrument load power, LOAD L1, may be obtained from a separate power source in phase with the instrument power supply. Instrument signal light will not operate unless instrument L2 and instrument load L2 are connected as shown. Instrument signal light will not operate if LOAD L1 is powered by a separate source of less than 100 Vac rms.

   Instrument load may be either a contactor coil, a Barber-Colman SOLID STATE CONTACTOR, or heater.

   Rating of Solid State Switching Output: (both ON-OFF and Time-Proportioning): 1A continuous, 10A inrush, 50mA minimum. Any voltage from 24 Vac to 240 Vac can be switched but the voltage switched must be the same phase and have the same common line as the instrument power supply.

2.9 Setpoint Wiring — Isolated

2.9.1 Input Setpoint Wiring (Setpoint Options 2, 5, 7 and 8)

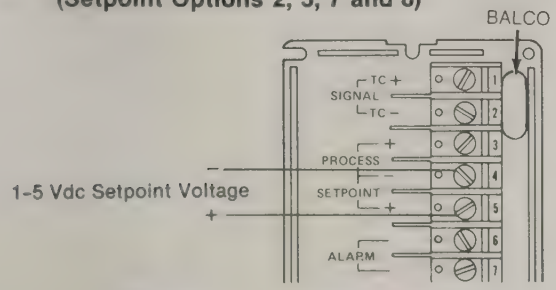


Figure 2-11. Setpoint Wiring

Notes:

1. **Options 2 or 5:** Setpoint with Remote-Local Switch.

   Source should be free of transients and have an impedance less than 200 ohms. For operation of more than one controller from the same external source, a source resistance under 50 ohms is recommended. Typical input impedance of 1 meg ohm.

   A REMOTE-LOCAL switch on the front panel allows the setpoint source to be either the front panel setpoint or the remote setpoint. For start-up or servicing the instrument may be switched to local setpoint operation. After start-up or servicing, control is returned to the remote setpoint.
2. **Option 7:** No Setpoint, requires remote setpoint voltage.

   Source should be free of transients and have an impedance less than 200 ohms. For operation of more than one controller from the same external source, a source resistance under 50 ohms is recommended.
3. **Option 8:** Trim Setpoint

   Requires 1–5 Vdc Setpoint Voltage from an external source. Source resistance up to 20 ohms.

   The Trim Control, located in place of the Digital Setpoint, adjusts the remote 1–5 Vdc input setpoint signal ±5% of span. Typical input impedance is 20k ohms.

   The input setpoint signal is usually trimmed to either correct for sensor difference or to select a desired temperature profile.

2.9.2 Output Setpoint Wiring (Setpoint Options 3 or 6)

1–5 Vdc proportional to instrument setpoint span. Short circuit has no effect on control action. Source resistance less than 10 ohms.

The Series 520 operates as a Master Controller which can transmit a 1–5 Vdc output setpoint voltage to many multiple Slave Controllers.

Maximum total output current of Process Signal Output option plus Output Setpoint Voltage option is 10 mAdc.

2.10 Process Signal Wiring — Isolated

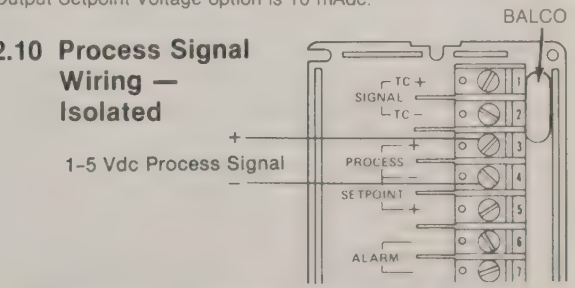


Figure 2-12. Process Signal Output Wiring (Setpoint Options 2, 3, 5, 6, 7 and 8)

External short circuit has no effect on control action. Source resistance less than 10 ohms.

Setpoint options 2, 3, 5, 6, 7 and 8 include Interface Signal Isolation. This means that the Process Signal and Setpoint Signal Outputs are isolated from the signal input terminals. There is also Input-Output Isolation.

Model number located under access door. Specify complete 15-digit model number on any inquiry to Barber-Colman Company.

52□□ - □ □□□□ - □□□ - □ - □□

Series

Control Mode
1 — ON-OFF or Limitrol (only with A, L or T below)
2 — Proportional Controller
3 — Proportional + Integral (Reset)
4 — Proportional + Integral + Derivative (Rate)

Output Control Form
A — ON-OFF (only with 1 above)
B — Time Proportioning
C — Current: 2-12 mA, Reverse Acting
D — Current: 4-20 mA, Reverse Acting
E — Dual—Time Proportioning and on-off auxiliary output
F — Dual—Current 2-12 mA and on-off auxiliary output
G — Dual—Current 4-20 mA and on-off auxiliary output
H — Dual—Time Proportioning on both outputs
J — Dual—Current 2-12 mA and Time Proportioning auxiliary output
K — Dual—Current 4-20 mA and Time Proportioning auxiliary output
L — Limitrol (only with 1 above)
P — Current: 2-12 mA, Direct Acting
Q — Current: 4-20 mA, Direct Acting
T — Limitrol (only with 1 above)

Setpoint
1 — Analog Setpoint
2 — Analog Setpoint with Remote-Local Switch
3 — Analog Setpoint with output setpoint voltage available
4 — Digital Setpoint (standard)
5 — Digital Setpoint with Remote-Local Switch
6 — Digital Setpoint with output setpoint voltage available
7 — None. Requires remote setpoint voltage
8 — Trim Setpoint. Requires remote setpoint voltage
9 — Other

Setpoint options **2, 3, 5, 6, 7** and **8** include a Process Signal Output

Range Code
Four Digit Range Code

Input Signal
0 — Thermocouple Upscale TCB
1 — Thermocouple Downscale TCB
2 — Resistance Bulb
4 — Vdc (above 0.1 Vdc)
5 — mAdc
6 — Radiation Pyrometer Emissivity Correction
8 — mVdc (below 100 mVdc)
9 — Other

Readouts
1 — Deviation Meter (standard)
3 — Process Meter
5 — Digital Process Meter
7 — Deviation Meter with 1.8 Inch Scale

Housing
0 — Panelmount (standard)
1 — Shipped without housing—order housing separately
2 — Panelmount with conduit openings and rear cover

Specify 1 above and see 1252 DB 3 to order high density housings for either Panel or Standard Relay Rack Mounting.

Alarms
0 — None (standard)
1 — Deviation Alarm
2 — Deviation Band Alarm
3 — Process Alarm

Specials
00 — None. Consult factory for all Specials

All of the models include, as standard, indicator lights appropriate to the output form selected.

CALIBRATION CHARTS, DIGITAL SETPOINT ONLY

0 TO 799°F/J
DIGITAL RANGE CODE 0016

True Temp °F	Dial Setting or DPM Reading	Setpoint Voltage	Input mV
0	12	1.059	-0.89
50	57	1.286	0.51
100	104	1.520	1.94
150	152	1.759	3.41
200	200	2.003	4.91
250	250	2.250	6.42
300	299	2.499	7.95
350	349	2.749	9.48
400	400	3.000	11.02
450	450	3.252	12.57
500	500	3.503	14.11
550	550	3.754	15.65
600	600	4.005	17.19
650	650	4.255	18.72
700	700	4.505	20.25
750	750	4.755	21.78
799	799	5.000	23.29

0 TO 598°F/J
DIGITAL RANGE CODE 0015

True Temp °F	Dial Setting or DPM Reading	Setpoint Voltage	Input mV
0	10	1.069	-0.89
25	33	1.219	-0.20
50	56	1.373	0.51
75	79	1.528	1.22
100	103	1.686	1.94
125	127	1.846	2.67
150	151	2.007	3.41
175	175	2.170	4.16
200	200	2.333	4.91
225	224	2.498	5.66
250	249	2.664	6.42
275	274	2.830	7.18
300	299	2.997	7.95
325	324	3.165	8.71
350	349	3.333	9.48
375	375	3.501	10.25
400	400	3.669	11.02
425	425	3.838	11.79
450	450	4.006	12.57
475	475	4.175	13.34
500	501	4.343	14.11
525	526	4.511	14.88
550	551	4.679	15.65
575	576	4.847	16.42
598	599	5.000	17.12

200 TO 1190°F/J
DIGITAL RANGE CODE 0203

True Temp °F	Dial Setting or DPM Reading	Setpoint Voltage	Input mV
200	202	1.010	4.91
250	251	1.206	6.42
300	301	1.404	7.95
350	351	1.603	9.48
400	401	1.803	11.02
450	451	2.003	12.57
500	501	2.203	14.11
550	550	2.403	15.65
600	600	2.603	17.19
650	650	2.802	18.72
700	700	3.000	20.25
750	749	3.199	21.78
800	799	3.398	23.32
850	849	3.597	24.85
900	899	3.797	26.40
950	949	3.999	27.95
1000	1000	4.202	29.52
1050	1051	4.407	31.10
1100	1103	4.616	32.71
1150	1156	4.827	34.34
1190	1199	5.000	35.67

0 TO 1999°F/K
DIGITAL RANGE CODE 0030

True Temp °F	Dial Setting or DPM Reading	Setpoint Voltage	Input mV
0	13	1.027	-0.69
100	109	1.217	1.52
200	208	1.415	3.82
300	305	1.611	6.09
400	401	1.803	8.31
500	498	1.996	10.56
600	597	2.194	12.85
700	697	2.394	15.18
800	798	2.596	17.52
900	899	2.800	19.88
1000	1001	3.004	22.25
1100	1103	3.208	24.62
1200	1205	3.411	26.98
1300	1305	3.612	29.31
1400	1405	3.812	31.63
1500	1504	4.009	33.91
1600	1601	4.203	36.17
1700	1696	4.394	38.39
1800	1790	4.583	40.58
1900	1883	4.768	42.73
1999	1974	4.950	44.83

Barber-Colman Company
INDUSTRIAL INSTRUMENTS DIVISION
1700 Rock Street, Rockford, Illinois, U.S.A., 61101

MODELS 521, 522, 523 AND 524
MAIN BOARD CIRCUITS, AND CALIBRATION
(Includes Wiring Diagram and Replaceable Mechanical Parts)

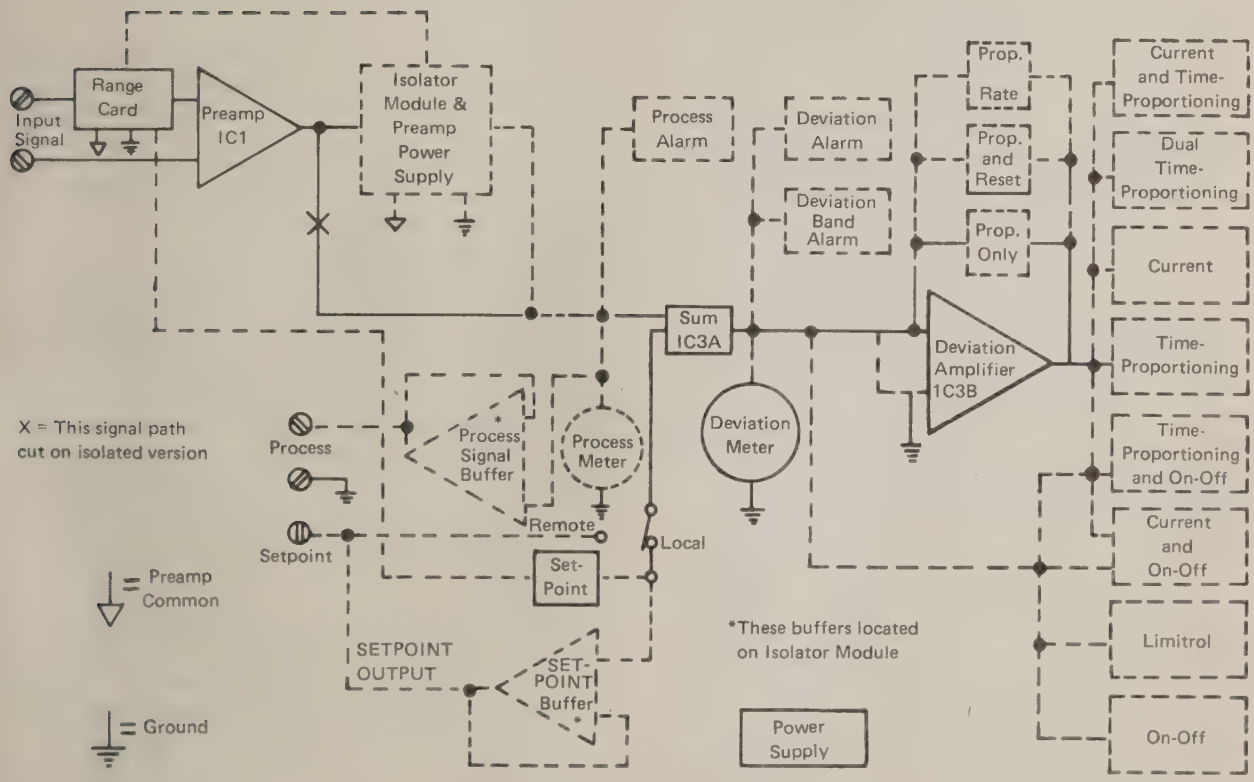


Figure 3-1. Simplified Block Diagram.

3. INTRODUCTION

3.1 General Description

Descriptions common to all models of the Series 520 are included in this section. Figures showing replaceable mechanical parts and a wiring diagram for all models are at the end of the section.

3.2 Main Board

3.2.1 OVERALL DESCRIPTION

See Figure 3-1. For a thermocouple input, the signal to the Preamplifier is the thermocouple signal minus the cold junction reference signal. The Preamplifier amplifies the direct current millivolt input signal to drive an optional process meter and an optional alarm board. When the temperature of the input thermocouple and the temperature set on the front panel setpoint are the same, the output (error signal) of the SUM network on the Main Board is zero. At zero error signal, the input to the deviation meter will be zero, and it will indicate zero deviation. Any signal other than zero is amplified by the Deviation Amplifier. Gain plus Manual Reset or Gain plus Integral plus Derivative action takes place on a separate board. The Demand Signal from the Deviation Amplifier drives the output control board. ON-OFF Control Forms such as the 520L, T, and A and Output 2 of the E, F, and G receive a driving signal directly from the Sum Amplifier output (deviation signal).

3.2.2 CIRCUIT DESCRIPTION

See Schematic Figure 3-3.

3.2.2.1 Preamplifier IC1

The gain is fixed by resistors R6 and R7 on the Range Board. The output of IC1 on pin 10 which ranges from 2 to 10 Vdc is the amplified process signal. This process signal drives the front panel process meter, and also appears on rear panel terminals 3 and 4.

R8 and R9 on the Isolator Board divides the 2 to 10 Vdc down to 1 to 5 Vdc. IC2B is a buffer stage that prevents instrument control from being affected if terminals 3 and 4 are shorted.

3.2.2.2 IC3A Sum

IC3A on the Main Board sums the process signal with the setpoint signal. The output of IC3A on pin 1 is the deviation signal.

3.2.2.3 Current Source IC4 for the Setpoint Voltage

The voltage reference source for the current source is resistor divider R20, R21 and trimpot R22. The 5 Vdc reference voltage is connected across the digital setpoint resistance and R9 on the Range Board. Changing the numerical value of the digits on the setpoint changes the resistance in the emitter leg of Q2 and generates the 1–5 Vdc setpoint signal in the collector of Q2.

3.2.2.4 Op Amp IC3B

IC3B is the deviation amplifier for amplifying the deviation signal to supply a demand signal. The gain adjustment is R23. When manual reset is furnished with the Proportional only Control Mode, the manual reset voltage is summed with the deviation signal on pin 5 of IC3B. The demand signal output on pin 7 of IC3A drives the output control form board. The amplifier also sums the correction signal from either the PI or PID boards.

3.2.2.5 Power Supplies +15 Vdc, -15 Vdc & -30 Vdc

The -30 Vdc supply has only its transformer on the Main Board. The remainder of its circuit is on any output control form board with a current output. The ac voltage from the transformer is on pins 10 and 11 of P5. The +15 Vdc potential is established by IC2 which is an integrated circuit regulator. The +15 Vdc voltage is adjusted by R18. Zener diode D5 and series pass transistor Q1 provides the regulation for the -15 Vdc supply.

3.2.2.6 Setpoint Options 1 and 4: – Setpoint Only

This is the internal setpoint only. Option 4 is standard.

3.2.2.7 Setpoint Options 2 and 5: – Setpoint With Remote Local Switch

This simple circuit switches between remote and internal terminals. The 1–5 Vdc remote setpoint signal is filtered by R30 and C14 and then summed with the process signal from IC1A on the Isolation Board.

3.2.2.8 Setpoint Options 3 and 6: – Setpoint With Output Setpoint Voltage Available

IC3 on Isolation Board is a buffer with a low output impedance. IC3 prevents loss of control action should rear panel terminals 4 and 5 be shorted.

3.2.2.9 Setpoint Option 7: – No Built-in Setpoint, Accepts Remote Setpoint Voltage

The 1–5 Vdc remote setpoint signal is filtered by R30 and C14, and then summed with the process signal from IC1A of Isolation Board.

3.2.2.10 Setpoint Option 8: – Trim Setpoint. Requires Remote Setpoint Voltage

See Figure 3-4.
This option is on board A-10278 located on the rear of the front panel mounted Trim Control. The Trim Control replaces the standard digital setpoint. The 1–5 Vdc remote setpoint signal is summed with a trim setpoint voltage, which is at a potential of ±5% of setpoint span. This "new" setpoint voltage is then summed with the process signal from IC1A.

3.2.3 CALIBRATION

3.2.3.1 General

All adjustments are factory set and normally do not require readjustment. Verification of instrument accuracy within specifications, or determination if recalibration is necessary, can be determined by performing the calibration check procedures.

3.2.3.2 Calibration Equipment

The following equipment is required to calibrate this controller:

1. Differential Voltmeter with 10 mV full scale or less such as Fluke Model 871AB or a Portable Potentiometer such as the Barber-Colman Model PA11-1. Hewlett-Packard Model 427A.

2. Dc millivolt source with outputs of 0–1 mVdc and 0–100 mVdc. Source resistance must be 50 ohms or less.

3. Extender assembly 24-2 for Calibration or Troubleshooting.

Proceed through the following paragraphs in order. Do not skip a paragraph.

3.2.3.3 Calibration Check

THE EXAMPLES IN THIS CALIBRATION CHECK IN PARENTHESES ARE FOR RANGE CODE 0030 (0 to 2000° F, TYPE K).

1. Connect a millivolt source to the sensor input terminals. If the sensor is a thermocouple, be certain the correct thermocouple extension wire is used.

2. Set the millivolt source to the value shown in the Calibration Table for mid-scale temperature. (Example: 1000°F=22.25mV).

3. Connect a precision voltmeter to read the deviation voltage. Positive probe to pin 1 of P5, negative probe to pin 7 of P5.

4. Adjust the controller setpoint until the deviation voltage is 0 ± .025Vdc.

5. The setpoint reading must agree with the "Dial Setting" value shown in the Calibration Table within the rated accuracy of the instrument. (Example: 1001±20).

   ±1% of span plus 0.5% of suppression.

6. Set the millivolt source to the millivolt value corresponding to a temperature which is listed in the Calibration Table and which falls between 10 and 20% of span above the low point of the range. (Example: 200°F=3.82mV).

7. Adjust the controller setpoint until the deviation voltage is 0±.025Vdc.

8. The setpoint reading must agree with the "Dial Setting" value shown in the Calibration Table within the rated accuracy of the instrument. (Example: 208±20).

9. Set the millivolt source to the millivolt value corresponding to a temperature which is listed in the Calibration Table and which falls between 80 and 90% of span above the low point of the range. (Example: 1800°F=40.58mV).

10. Adjust the controller setpoint until the deviation voltage is 0±.025Vdc.

11. The setpoint reading must agree with the "Dial Setting" value shown in the Calibration Table within the rated accuracy of the instrument. (Example: 1790±20).

    ±1% of span plus 0.5% of suppression.

12. If the controller meets the accuracy specifications in steps 5, 8, and 11, the controller is properly calibrated. Do not make any internal adjustments or proceed further in the calibration procedure.

13. If the controller fails to meet the accuracy specifications in either step 5, 8, or 11, the controller must be calibrated.

Table 3-1 lists the adjustments on the Main Board. Always perform the adjustments on the Main Board first. When a Range Board is replaced, readjust R8 and R22 on the Main Board. After replacing either a Process Meter, or a Deviation Meter, readjust R10 on the Main Board.

If any repairs are made, all the adjustments on the Main Board, Control Mode Board (if any) and Output Board (if any) must be made.

Table 3-1. Summary of Adjustments on Main Board

Symbol	Description
R18	+15 Vdc Supply
R22	3 Vdc Setpoint Voltage (MID SPAN)
R8	6 Vdc Process Signal (MID SPAN)
R10	Process Meter Span or Deviation Meter Span

3.2.3.4 Meter Zero

Both the Process and Deviation Meters have a mechanical zero adjustment on the top of the meter. It is covered by tape. Remove the tape.

For the Deviation Meter with the instrument vertical, zero the meter with a non-magnetic screwdriver, and replace the tape. After a Deviation Meter is zeroed, place the instrument in the panel and be sure the meter is still at zero. This detects if any magnetic flux in the panel is present to offset the meter — if the meter is offset, zero it in the panel.

Apply 1Vdc across the terminals of the Process Meter before zeroing it.

Replace the tape.

3.2.3.5 ±15 Vdc Supply — 1st Check

A voltmeter capable of reading voltages to five significant figures in the range of 0–16 Vdc is required. Assuming such a voltmeter is available, proceed as follows:

1. Turn power on to the Series 520.

2. Set the voltmeter to read up to 16.000 Vdc.

3. Connect the probes of the voltmeter across the 15 Vdc supply (positive probe to pin 11 of P2, negative probe to pin 10). To locate these pins look at P2 on the Range Board. There are 11 pins on P2, and they are numbered 1 through 11, from left to right.

4. Adjust R18 until 15.000 Vdc±.015 Vdc is obtained.

5. Remove the probes.

6. Seal R18.

7. The -15 Vdc supply can be measured between pins 5 and 7 of P5 Output Board. Connect the positive probe to pin 7 and the negative probe to pin 5. The voltage read should not be less than 13.650 Vdc or more than 15.150 Vdc. To locate these pins first look at the board parts location drawing in the Output section of this manual.

8. Allow power to remain on to the instrument.

3.2.3.6 Setpoint

3.2.3.6.1 Digital

2 N D Check

1. Turn the front panel SETPOINT ADJUST control to mid span of the setpoint range. (Example: 1000°F).

2. Set the voltmeter to read up to 4.000 Vdc.

3. Connect the positive probe of the voltmeter to pin 1 of P2 and the negative probe of the voltmeter to pin 10 of P2.

4. Adjust R22 until 3.000 Vdc±.003 Vdc is obtained.

5. Seal R22.

6. Allow power to remain on to the instrument.

3.2.3.6.2 Analog

1. Connect the positive probe of the voltmeter to the blue wire on the Analog Setpoint Board A-10503. Connect the negative probe to pin 10 of P2 on the Range Board.

2. Remove the setpoint knob.

3. Turn the SETPOINT ADJUST Control fully CCW. Observe the reading on the voltmeter. Slowly turn the SETPOINT ADJUST Control CW until a 25 mVdc change is observed on the voltmeter.

4. Reinstall the setpoint knob. Carefully align the pointer to the lowest scale value.

5. Adjust R5 on the Setpoint Board A-10503 for 1.000 Vdc±1 mVdc.

6. Turn the SETPOINT ADJUST Control fullscale.

7. Adjust R2 on the Setpoint Board for 5.000 Vdc±5 mVdc.

8. Repeat steps 5 through 7.

3.2.3.7 Deviation Signal Null

3 RD

1. Adjust the front panel SETPOINT ADJUST control to the setting on the Calibration Table that corresponds to the midspan of the instrument. (Not necessarily the same as midspan of setpoint) (Example: 1001 setting = 1000°F).

2. Connect the dc millivolt source to input terminals 1 and 2. Be certain the polarity of the connections is correct.

3. Adjust the D.C. millivolt source for the equivalent millivolts of the same midscale temperature used in step 1. (Example: 1000°F=22.25mV).

4. Measure the deviation output of IC3A as follows: Connect the positive probe to pin 1 of P5, and the negative probe to pin 7 of P5. The precision voltmeter should read 0 Vdc ±.025 Vdc. Adjust R8 for zero deviation.

5. Seal R8, if Isolation Board is not present.

6. Allow power to remain on to the instrument.

7. If Isolation Board is installed, proceed to Isolation Board Adjustments and lastly do the Meter Span Adjustment.

3.2.3.8 Meter Span

If the controller has a Deviation Meter set the input source for the equivalent of midscale temperature and adjust the setpoint for the maximum deviation that corresponds to the deviation meter scale. For example, assume the controller has a 0 to 400°F range and a Deviation Meter with a scale marked -30 to 0 to +30. Adjust the setpoint to 230°F. Deviation Meter should read -30° to within one major division. Adjust R10 if it does not. Next, adjust the setpoint to 170°F. Deviation Meter should read +30°F to within one major division. Adjust R10 if it does not.

If the controller has a process meter, it should be indicating mid span when the dc millivolt source is set for the equivalent of midscale temperature. If it does not, adjust R10 until it does.

Allow power to remain on to the instrument and next perform any adjustments (if any) for the Control Mode and Output Sections, respectively, of this manual.

Table 3-2. Complete Main Board Assemblies

Assembly Number	Setpoint Option	Description of Feature Making Board Different from Other Main Boards
A-11410-100	4	Digital Setpoint
A-11410-200	5	Digital Setpoint with Remote–Local Switch
A-11410-300	6	Digital Setpoint with output setpoint voltage
A-11410-400	7	No setpoint. Requires remote setpoint voltage
A-11410-500	8	Trim Setpoint. Requires remote setpoint voltage.
A-11410-600	1	Analog Setpoint
A-11410-700	2	Analog Setpoint with Remote–Local Switch
A-11410-800	3	Analog Setpoint with output setpoint voltage

Deviation Meter Part Numbers		
Part Number	Scale	Span (Units)
36-093-100	50-0-50	401-800
36-093-200	30-0-30	400 or less
36-093-300	100-0-100	801-1600
36-093-400	200-0-200	1601-3000
36-093	10-0-10	% Deviation

PROCESS METER
36-1XXXX
SPECIFY RANGE NUMBER WHEN ORDERING

FYRE-81 RECEPTACLE

A-10278 TRIM SETPOINT (△T) ASSEMBLY

PART OF ASSY A-10278

DEVIATION METER

34-754 NO. 6 CLOSED END TERMINAL

RED BLK BLU GRY GRN GRN WHT/GRN

PROCESS METER PART NUMBERS
PROCESS METER ASSEMBLY 36-1 XXXX
RANGE CODE OF INSTRUMENT

Adjustments on Main Board

Symbol	Description
R18	+ 15 Vdc Supply
R22	3 Vdc Setpoint Voltage (MID SPAN)
R8	6 Vdc Process Signal (MID SPAN)
R10	Process Meter Span or Deviation Meter Span

Control Farm	Lamp and Connector	Pin Connection		Lamp and Connector	Pin Connection		Lamp and Connector	Pin Connection	
A, B	36-91-101 Red	I	Alarm Board D or E	None Required			36-111-100 Amber	G	K
C, D, P, Q								G	H
E, H				36-110-100 White	F	J		G	K
F, G, J, K								G	H
L or T				Switch (S1)	Part of Limitrol Bd.		36-112-100 Red	G	N.C. Contact of Relay

32-372 REMOTE LOCAL SWITCH
CONNECTIONS FOR USE WITH DIGITAL S.P.
LOCAL
REMOTE
GRN YEL WHT

SEE BELOW FOR ANALOG SETPOINT CONNECTIONS

RED WHT/RED

PART OF ASSEMBLY A-10342 OR A-10343

SETPOINT SWITCH ASSEMBLIES		
Digits	Part Number	Digital Span
3	A-10342-100	0–X99
3	A-10342-200	200-X1199
3	A-10342-300	500-X1499
4	A-10343	0-X999
3	A-10342-400	1300-2399

ANALOG REMOTE–LOCAL SWITCH CONNECTIONS
LOCAL
REMOTE
GRN (TO POINT N – MAIN BOARD)
YEL (TO POINT M – MAIN BOARD)
BLU (FROM ANALOG SETPOINT – A-10503)

BLU RED
PART OF ASSEMBLY A-10503
A-10503 ANALOG SETPOINT
WHT/RED

P1 SIGNAL
PROCESS
P2 SET POINT
ISOLATION
ALARM
240 V
120 V
L2
T1
LOAD
OUTPUT 2
OUTPUT 1
CURRENT
GND
P3 CONTROL MODE
P5 CONTROL FORM
RANGE
JA JC JE

BLK TO DA01 POWER
WHT TRANSFORMER 1.20V
ORANGE PROCESS SIGNAL
YELLOW 15V
RED +15V
BLK COM
BLUE 20V (UNREG)
DIGITAL PROCESS METER WIRING

BLK BLK BLK BLK BLK PURPLE ORN WHT/RED GRN GRN BLK

LIMITROL OUTPUT ASSEMBLY CONTROL FORM BOARD

TO PIN K OR H (SEE TABLE NO. 1)
PART OF LAMP ASSEMBLY 36-91
S1
32-246 SWITCH S1 FOR LIMITROL OUTPUT CONTROL FORM ONLY

The following kits may be ordered to add an alarm to a controller without one.

Kit Number	Description
71-577	Deviation Alarm
71-578	Process Alarm
71-579	Deviation Band Alarm

When lead is connected to "D", light is "ON" when relay is not energized.
When lead is connected to "E", light is "OFF" when relay is not energized.

34-846 HIGH PROFILE RECEPTACLE

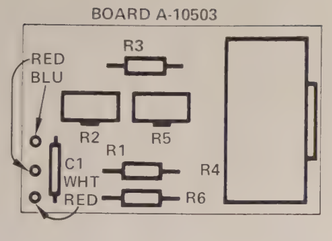
JUMPER "C" TO:
Position "A" (N.C.) contacts available to field terms.
Position "B" (N.O.) contacts available to field terms.

ALARM BOARD
Pin #

Figure 3-2. Wiring Diagram for All Models

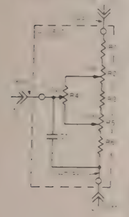
Table 3-3. Analog Setpoint Board A-10503 (Mounted on Analog Setpoint Pot)

Symbol	Part Number	Description
		CAPACITOR
C1	39-325	.05μF, 20%, 100 WVDC
		RESISTORS
R1	CYZR-864-256	3740 ohms, .5%, 1 8W
R2	29-399	Variable, 200 ohms, 20%, 1 2W
R3	CYZR-864-218	1500 ohms, .5%, 1 8W
R4	29-395	Variable, 20k ohms, 10%, 2W
R5	29-398	Variable, 100 ohms, 20%, 1 2W
R6	CYZR-861-151	332 ohms, 1%, 1 8W

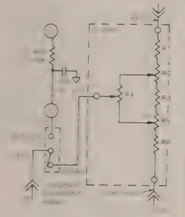


ANALOG OPTIONS

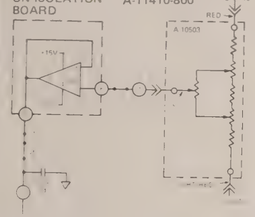
OPTION 1
ANALOG SETPOINT
ON MAIN BOARD A-11410-600



OPTION 2
ANALOG SETPOINT WITH REMOTE-LOCAL SWITCH
ON MAIN BOARD A-11410-700



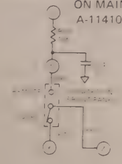
OPTION 3
ANALOG SETPOINT WITH OUTPUT SETPOINT VOLTAGE AVAILABLE
ON ISOLATION BOARD
ON MAIN BOARD: A-11410-800



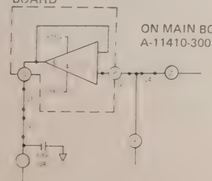
SETPOINT OPTIONS

OPTION 4
DIGITAL SETPOINT
ON MAIN BOARD A-11410-100

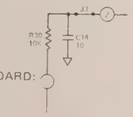
OPTION 5
DIGITAL SETPOINT WITH REMOTE–LOCAL SWITCH
ON MAIN BOARD: A-11410-200



OPTION 6 REMOTE SETPOINT
DIGITAL SETPOINT WITH OUTPUT SETPOINT VOLTAGE AVAILABLE
ON ISOLATION BOARD
ON MAIN BOARD: A-11410-300



OPTION 7
REMOTE SETPOINT
ON MAIN BOARD:



OPTION 8
WITH TRIM (△T)

FOR MAIN BOARD: A-11410-500

(See Fig. 3-4)

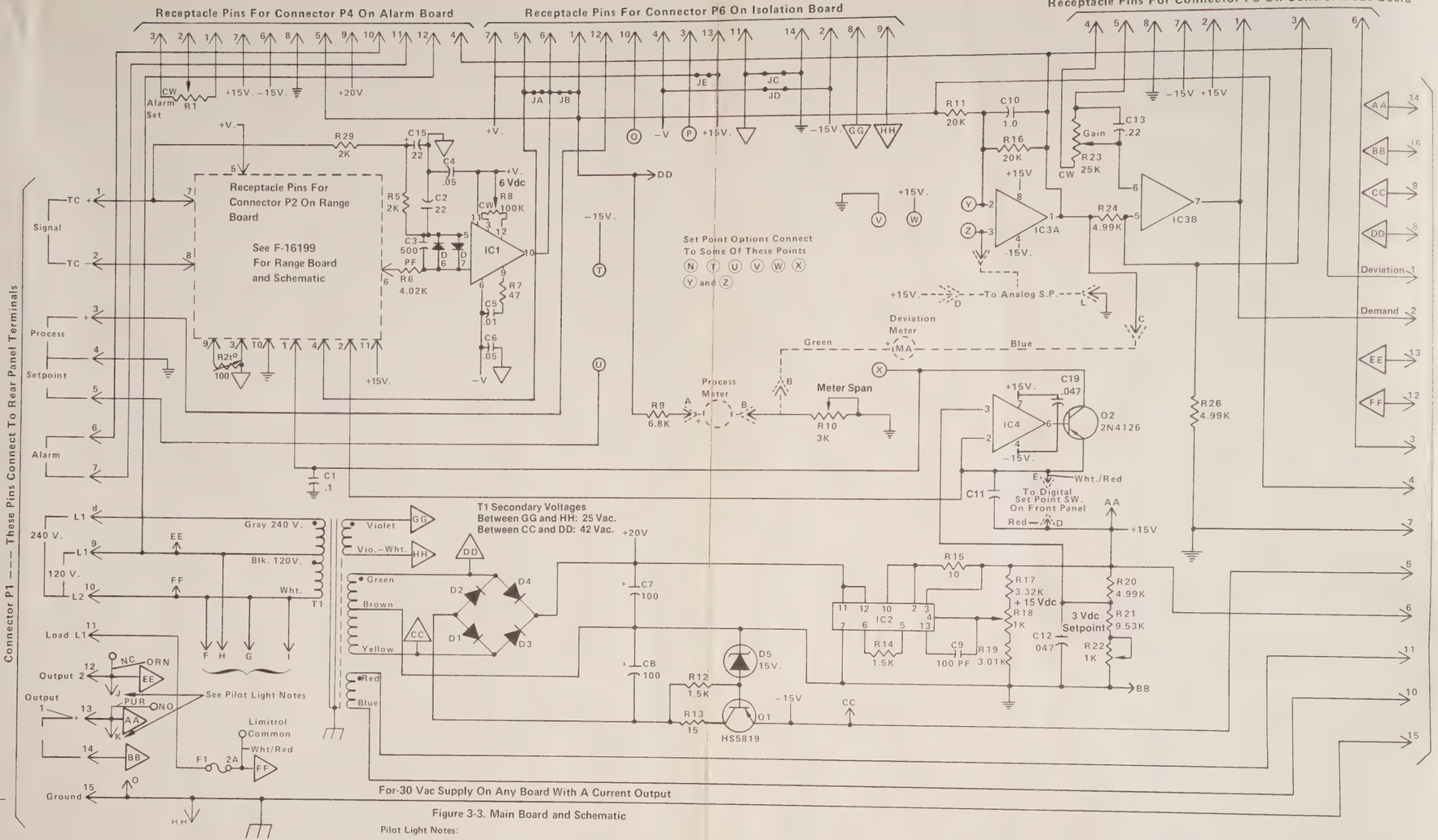

Receptacle Pins For Connector P4 On Alarm Board
Receptacle Pins For Connector P6 On Isolation Board
Receptacle Pins For Connector P3 On Control Mode Board
Connector P1 — These Pins Connect To Rear Panel Terminals
Receptacle Pins For Connector P5 On Output Board
Receptacle Pins For Connector P2 On Range Board
See F-16199 For Range Board and Schematic
Set Point Options Connect To Some Of These Points
N T U V W X Y and Z
T1 Secondary Voltages
Between GG and HH: 25 Vac.
Between CC and DD: 42 Vac.
For-30 Vac Supply On Any Board With A Current Output
See Pilot Light Notes
Limitrol Common
Wht/Red
Meter Span
Deviation Meter
To Analog S.P.
To Digital Set Point SW. On Front Panel
3 Vdc Setpoint
+15 Vdc
6 Vdc
Gain
HS5819
IC1
IC2
IC3A
IC3B
IC4
Deviation
Demand

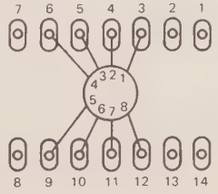
Figure 3-3. Main Board and Schematic

Pilot Light Notes:

1. For single time prop. or single on-off outputs, amber light is connected between pins G & K.
2. For dual time prop. or time prop. + on-off outputs, white light is connected between pins F & J and amber light is connected between pins G & K.
3. For current output, amber light is connected between pins G & H.
4. For current + on-off or current + time prop. outputs, white light is connected between pins F & J and amber light is connected between pins G & H.
5. For limitrol red light (left) is connected between pin G and N.C. contact of limitrol relay. Common of limitrol relay is connected to pin H.
6. For optional alarms, red light is connected between pin 1 and pins D N.C. or E N.O. on alarm board.
7. Jumpers JA, JB, JC, JD and JE are clipped, and Isolation Board

Table 3-3. Main Boards, Parts List

Symbol	Part Number	Description
	CAPACITORS	
C1	CYZR-803	.1μF 20%, 250WVDC
C2,15	39-414	22μF 10%, 15 WVDC
C3	39-387	500ρF 20%, 100 WVDC
C4,6	39-325	.05μF 20%, 100 WVDC
C5	39-103	.01μF 6 GMV, 100 WVDC
C7,8	39-163	100μF +100 -10%, 50 WVDC, Electrolytic
C9	39-069	100μF 5%, 600 WVDC
C10	CYZR-824	1ρF 20%, 100 WVDC
C11,12,19	39-449	.047μF 10%, 250 WVDC
C13	39-433	.22μF 10%, 250 WVDC
C14	39-400	10μF 20%, 15 WVDC (Only on A-11410-200, 400, & -700)
C18	39-449	.047μF 10%, 250 WVDC (Only on A-11410-300, -800)
	DIODES	
D1,2,3, 4,6,7	EYZP-384	Silicon, 250 PIV, 100 mA (Transition SG3087)
D5	37-204	Zener, 15V 5%, 400 mW
	FUSE	
F1	50-1223	20 Ampere, Type AGC 20 (Model 521L and 521T)
	SYZE-206	2 Ampere, Type AGC-2 (All other models)
	INTEGRATED CIRCUITS	
IC1	31-1011 or 31-1014	725C Operational Amplifier
IC2	31-1010	723C Voltage Regulator
IC3	31-1015 Dual	741C Minidip Operational Amplifier
IC4	31-1012	741C Minidip Operational Amplifier (omit on A-11410-600, -700, & -800)
	WIRE JUMPERS	
J1	Only on A-11410-300 & -800	
J2	Only on A-11410-300	
J3	Only on A-11410-400	
J4	Only on A-11410-100 & -300	
J5	Only on A-11410-500	
J6	Only on A-11410-300, -500 and -800	
J7	Only on A-11410-800	
	TRANSISTOR	
Q1	31-162	HS5819
Q2	EYZP-623	2N4126 (omit on A-11410-600, -700, & -800)
	RESISTORS	
Resistors are 10% tolerance, 1/4W, unless otherwise stated.		
R1	29-380	Process ALARM Potentiometer: 50k ohms, 3/4W
R1	29-374	Deviation ALARM Potentiometer: 5k ohms 20%
R2	MYDA-29-60	100 ohms 1%
R5,29	CYZR-861-230	2k ohms 1%, 1/8W
R6	CYZR-861-259	4.02k ohms 1%, 1/8W
R7	40-1751	47 ohms
R8	29-220	Variable, 100k ohms, 3/4W
R9	40-1922	6.8k ohms
R10	BYZR-162-5	Variable, 3k ohms 30%
R11	CYZR-861-330	20k ohms 1%, 1/8W
R12	CYZR-481-150	1.5k ohms
R13	CYZR-466	150 ohms
R14	CYZR-862-218	2.5k ohms 1%
R15	CYZR-481-350	4.7 ohms
R16	CYZR-862-330	20k ohms 1%
R17	CYZR-864-251	33.2k ohms .5%, 1/8W
R18	29-383	Variable, 1k ohm 20%, 1/2W
R19	CYZR-864-247	3.01k ohms .5%, 1/8W
R20	CYZR-864-268	4.99k ohms .5%, 1/8W
R21	CYZR-864-295	9.53k ohms .5%, 1/8W
R22	29-383	Variable, 1k ohm 20%, 1/2W
R23	29-370	GAIN Potentiometer, 25k ohms 30%
R24,26	CYZR-862-268	4.99k ohms 1%
R30	CYZR-861-301	10K ohms 1%, 1/8 W (Only on A-11410-200, -400, & -700)
	TRANSFORMER	
T1	30-346-2	Power



View for Installing 31-1011 (Round Can IC) In Place Of 31-1014 (D.I.P.)

For Continuation of Circuit See Figure 3-3.

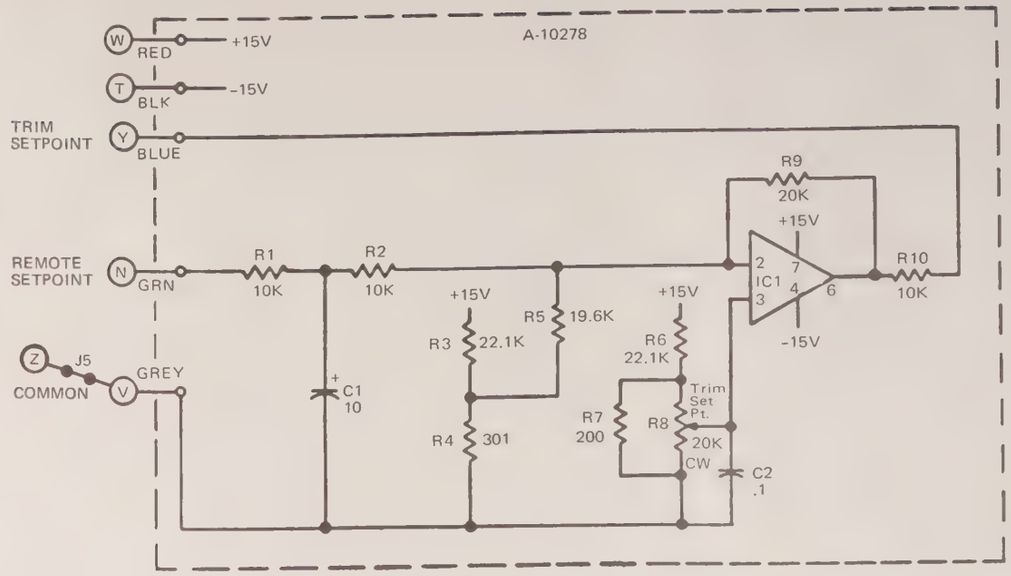
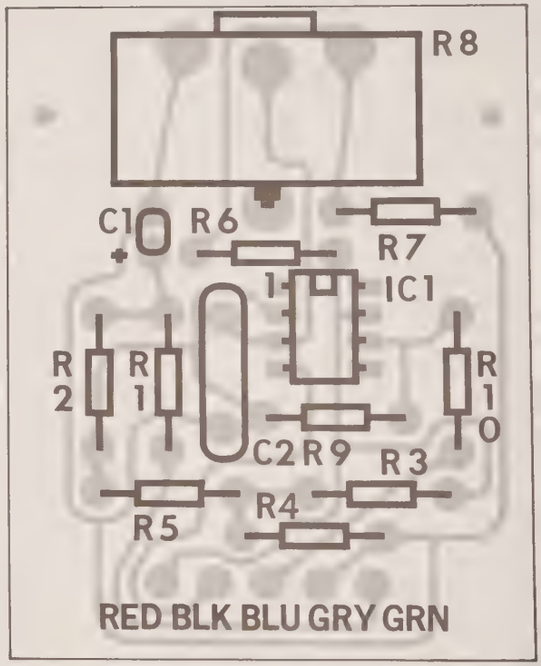


Table 3-4. Trim Setpoint Board A-10278 Parts List

Symbol	Part Number	Description
	CAPACITORS	
C1	39-400	10μF, 20%, 15 WVDC
C2	CYZR-803	.1μF, 10%, 250 WVDC
	INTEGRATED CIRCUIT	
IC1	31-1012	741C
	RESISTORS	
Resistors are 1%, 1/8W, unless stated otherwise.		
R1,2, 10	CYZR-861-301	10k ohms
R3,6	CYZR-861-334	22.1k ohms
R4	CYZR-861-147	301 ohms
R5	CYZR-861-329	19.6k ohms
R7	CYZR-861-130	200 ohms
R8	29-386	Variable, 20k ohms, 10%, 2W, W.W., TRIM Control
R9	CYZR-861-330	20k ohms



This board is located on the rear of the front panel mounted trim control.

Figure 3-4. Trim Setpoint Board and Schematic

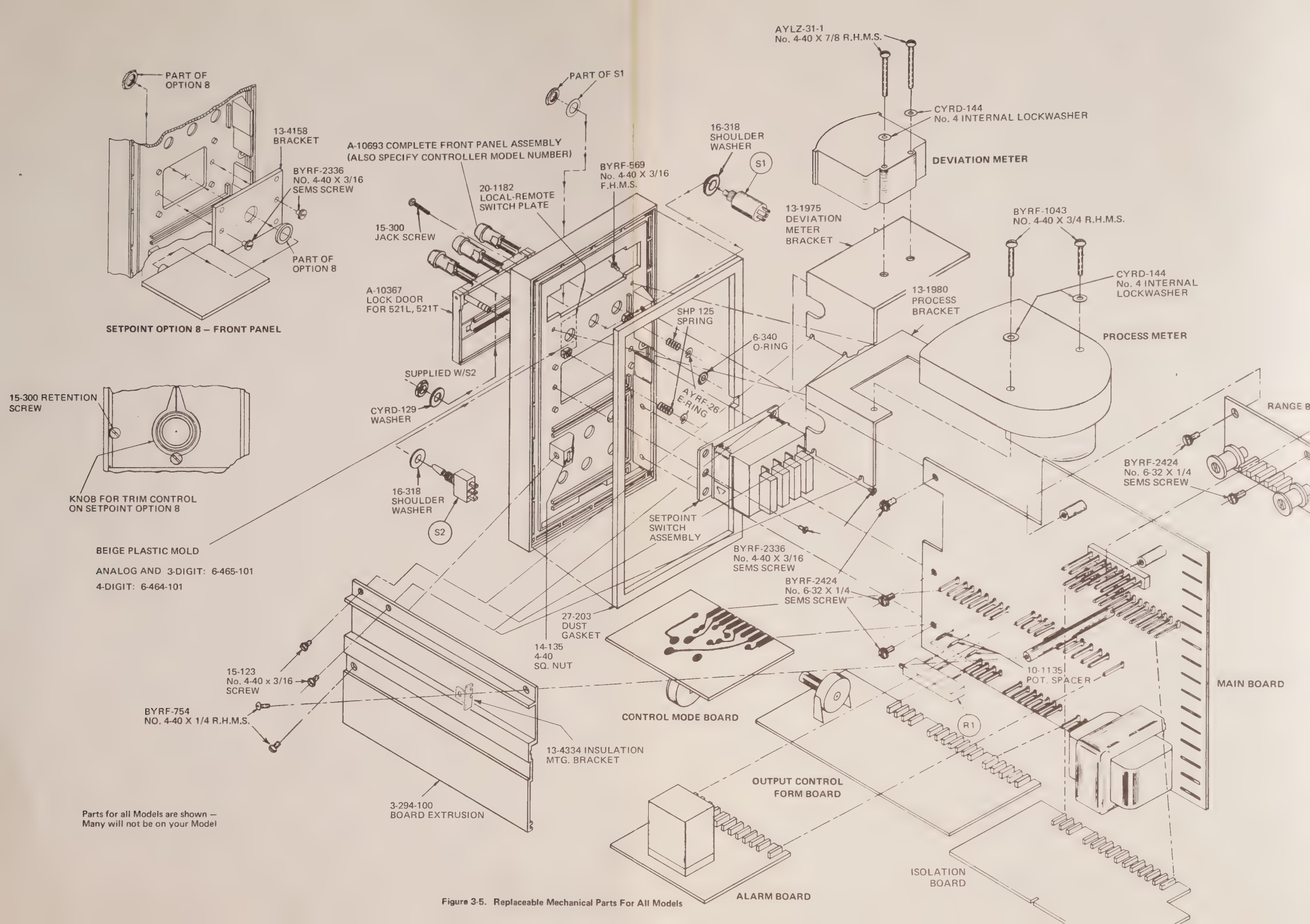

PART OF OPTION 8
13-4158 BRACKET
BYRF-2336 NO. 4-40 X 3/16 SEMS SCREW
PART OF OPTION 8
SETPOINT OPTION 8 – FRONT PANEL
PART OF S1
A-10693 COMPLETE FRONT PANEL ASSEMBLY (ALSO SPECIFY CONTROLLER MODEL NUMBER)
BYRF-569 No. 4-40 X 3/16 F.H.M.S.
20-1182 LOCAL-REMOTE SWITCH PLATE
15-300 JACK SCREW
A-10367 LOCK DOOR FOR 521L, 521T
SUPPLIED W/S2
CYRD-129 WASHER
16-318 SHOULDER WASHER
S2
15-300 RETENTION SCREW
KNOB FOR TRIM CONTROL ON SETPOINT OPTION 8
BEIGE PLASTIC MOLD
ANALOG AND 3-DIGIT: 6-465-101
4-DIGIT: 6-464-101
16-318 SHOULDER WASHER
S1
AYLZ-31-1 No. 4-40 X 7/8 R.H.M.S.
CYRD-144 No. 4 INTERNAL LOCKWASHER
DEVIATION METER
13-1975 DEVIATION METER BRACKET
BYRF-1043 NO. 4-40 X 3/4 R.H.M.S.
CYRD-144 No. 4 INTERNAL LOCKWASHER
13-1980 PROCESS BRACKET
PROCESS METER
SHP 125 SPRING
6-340 O-RING
AYRF-36 E-RING
SETPOINT SWITCH ASSEMBLY
RANGE B
BYRF-2424 No. 6-32 X 1/4 SEMS SCREW
BYRF-2336 No. 4-40 X 3/16 SEMS SCREW
BYRF-2424 No. 6-32 X 1/4 SEMS SCREW
27-203 DUST GASKET
14-135 4-40 SQ. NUT
15-123 No. 4-40 x 3/16 SCREW
BYRF-754 NO. 4-40 X 1/4 R.H.M.S.
13-4334 INSULATION MTG. BRACKET
3-294-100 BOARD EXTRUSION
CONTROL MODE BOARD
10-1135 POT. SPACER
MAIN BOARD
R1
OUTPUT CONTROL FORM BOARD
ISOLATION BOARD
ALARM BOARD
Parts for all Models are shown — Many will not be on your Model

Figure 3-5. Replaceable Mechanical Parts For All Models

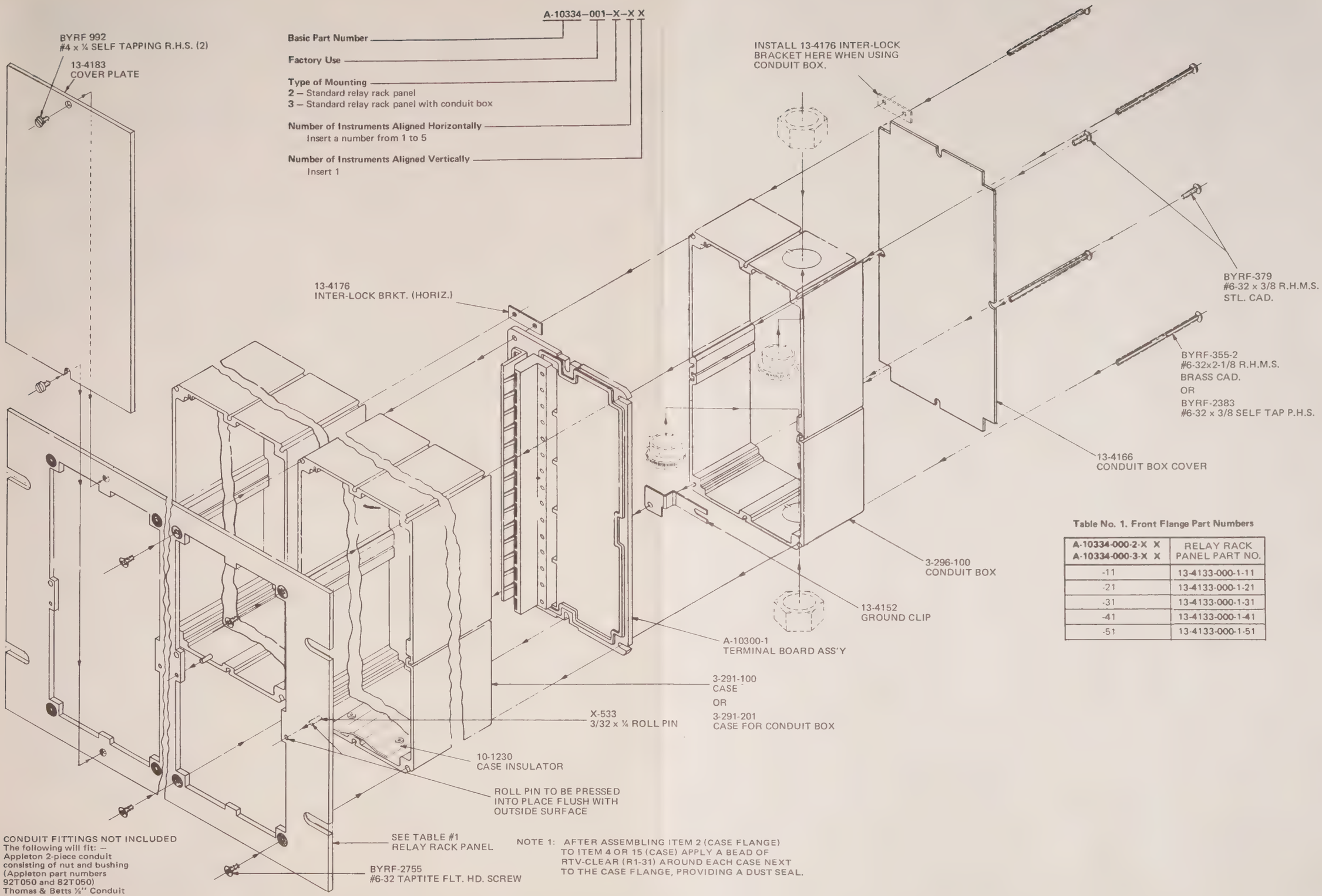


Table No. 1. Front Flange Part Numbers

A-10334-000-2-X X A-10334-000-3-X X	RELAY RACK PANEL PART NO.
-11	13-4133-000-1-11
-21	13-4133-000-1-21
-31	13-4133-000-1-31
-41	13-4133-000-1-41
-51	13-4133-000-1-51

Figure 3-6. Replaceable Parts, Housings for Standard Relay Rack

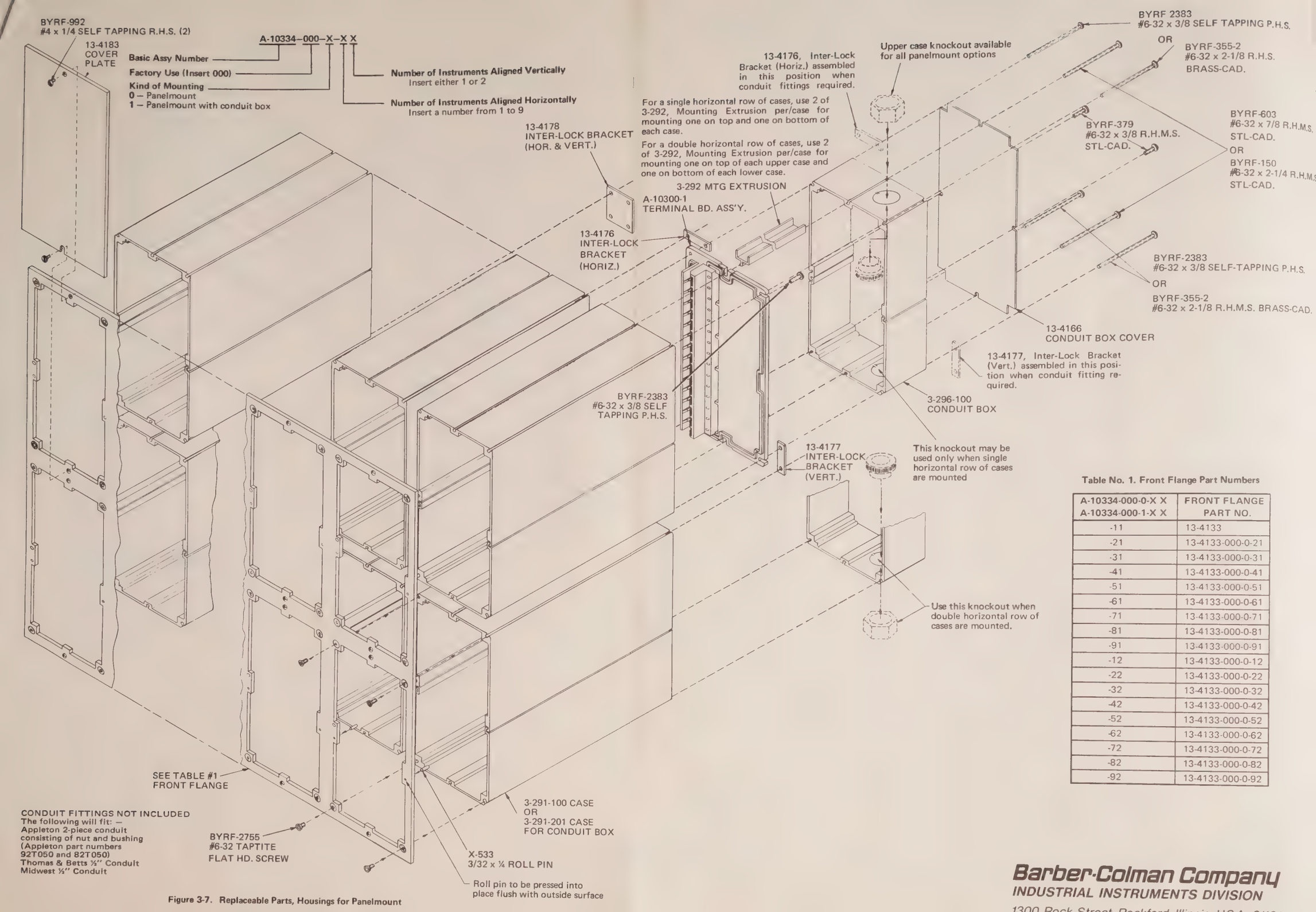


Figure 3-7. Replaceable Parts, Housings for Panelmount

Table No. 1. Front Flange Part Numbers

A-10334-000-0-X X A-10334-000-1-X X	FRONT FLANGE PART NO.
-11	13-4133
-21	13-4133-000-0-21
-31	13-4133-000-0-31
-41	13-4133-000-0-41
-51	13-4133-000-0-51
-61	13-4133-000-0-61
-71	13-4133-000-0-71
-81	13-4133-000-0-81
-91	13-4133-000-0-91
-12	13-4133-000-0-12
-22	13-4133-000-0-22
-32	13-4133-000-0-32
-42	13-4133-000-0-42
-52	13-4133-000-0-52
-62	13-4133-000-0-62
-72	13-4133-000-0-72
-82	13-4133-000-0-82
-92	13-4133-000-0-92

Barber-Colman Company
INDUSTRIAL INSTRUMENTS DIVISION
1300 Rock Street, Rockford, Illinois, U.S.A., 61101

E-14851-5 RK OCTOBER 1976

DIGITAL INDICATOR ASSEMBLY, A-11892-XXX

GENERAL

This bulletin is a supplement to F-14851 for controller Models 521, 522, 523, and 524; and to F-15098 for High-Power Switching Models 525, 526, 527, and 528.

Digital Indicator Assembly, A-11892-XXX is the horizontal circuit board located in the upper front area on 520 Series Controllers. The power transformer for the Digital Indicator is mounted under the A-11892-XXX circuit board.

DESCRIPTION

Model A-11892-000 (4-Digit Indicator) can display ranges from -400 to +1999. Model A-11892-100 (5-Digit Indicator) can display ranges from -4000 to +19999.

FEATURES

- 4 or 5-Digit Bipolar Display with Automatic Polarity Indication.
- Accurate Analog-to-Digital Conversion using Dual-Slope Integration.
- Overrange Blanking (Display shows -1 _ _ _)
- High Resolution Zero and Span Adjustments
- Advanced Design Requires Fewer Active Components (Two Integrated Circuits perform all basic functions)

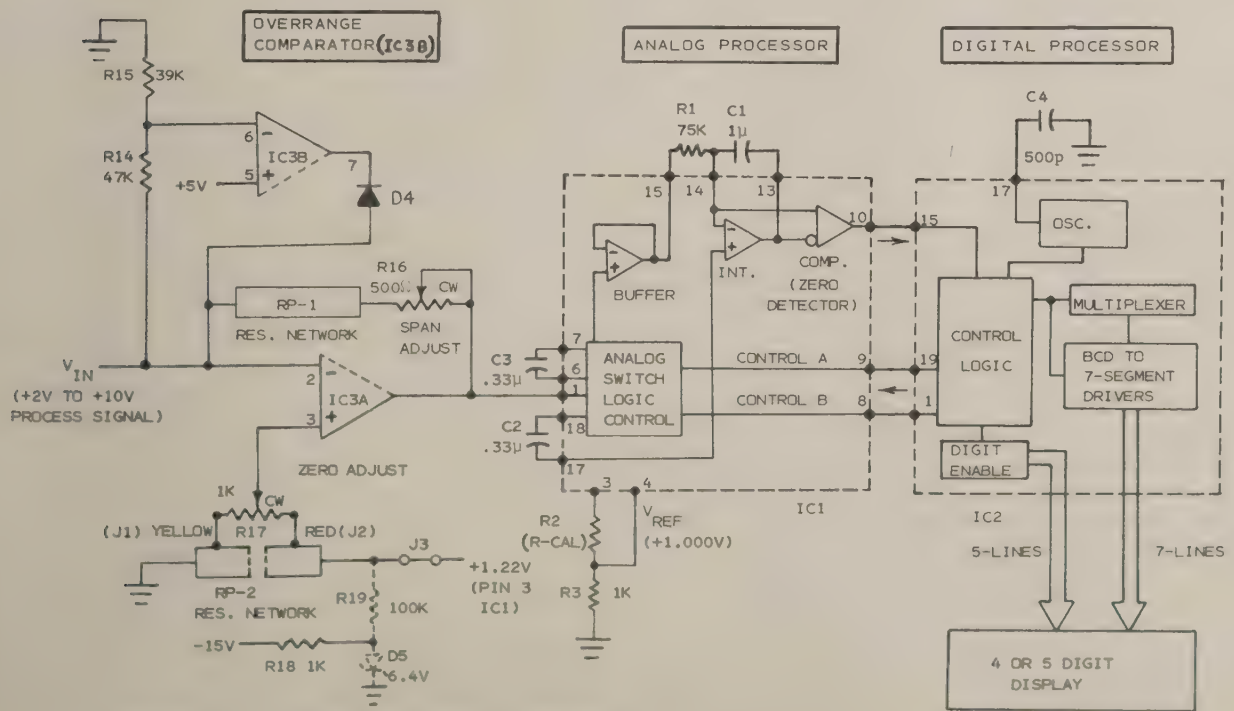


FIGURE 1. A-11892-XXX DIGITAL INDICATOR BLOCK DIAGRAM

CIRCUIT DESCRIPTION AND OPERATION

The advanced design of the A-11892-XXX Digital Indicator requires fewer active components to perform all basic functions for digital display of process temperature.

Power requirements for the Digital Indicator are +5 Vdc (provided by the A-11892-XXX circuit board supply) and -8 Vdc minimum (derived from the -15 Vdc supply on the 520 main board).

High accuracy is achieved in Analog-to Digital signal conversion by utilizing the proven method of Dual-Slope Integration. Analog Processor, IC1, and Digital Processor, IC2, form the heart of the system. Operating together, they convert a conditioned analog Process signal to drive the large (.362"), easy to read, digital display.

Process input (V_{IN}), +2 to +10 Vdc, is attenuated or scaled by IC3A providing up to ±2 Vdc output before entering Analog Processor, IC1. ZERO and SPAN adjustments (R17 and R16) are 25 turn potentiometers (providing high resolution) for final calibration of the digital indicator.

Shorting Block Jumpers (1 through 6), Soldered Wire Jumpers (J1, J2, and J3), and selected components (D5 and R19) must be added or omitted as described in Range Selection Table 3.

For ranges not listed, consult factory for correct jumper and component arrangement.

Overrange Comparator IC3B will generate an output signal to blank the display (-1 _ _ _) whenever the maximum Process temperature (as setup in Range Selection Table 3) is exceeded. A process input signal (V_{IN}) over +11 Vdc will drive the output of IC3B to -6 Vdc. The output of IC3A is then driven to +3.75 Vdc signaling IC1 and IC2 to blank the display (-1 _ _ _).

Analog Processor, IC1, performs several functions including generation of an accurate and stable source voltage. This source voltage is used to establish the reference voltage needed (at pin 4 of IC1) for Dual-Slope Integration.

The source voltage used (+1.22 Vdc ±8%) for establishing the reference is internally generated by IC1 and appears at pin 3. Resistors R2 (R-CAL) and R3 (1KΩ) divide this stable source voltage to the required +1.000 Vdc reference value (at pin 4 of IC1) for Dual-Slope Integration.

The source voltage at pin 3 of IC1 can ran from +1.1200 Vdc to +1.3200 Vdc. Resistor (R-CAL) is selected from Table 2 to provid the final +1.000 Vdc ±1% reference voltage required at pin 4.

IC1 also provides: 1) automatic compensati of internal zero offsets (in IC1) via Capacitor C2, 2) integrates the differenti voltage across pins 1 and 2 through C1 and R1, and 3) integrates the negative of the reference voltage stored on C3. The final output on IC1 (pin 10) is a high or low comparator signal. Two control lines (from IC2) appear at IC1 input pins 8 and 9 to control the Internal Logic Switch.

Digital Processor, IC2, is designed to complement Analog Processor, IC1. It features overrange blanking, an internal 120 KHz oscillator (set by C4), 7-segment display output drivers, and 5 multiplexed digit-enable outputs. Advanced I^2L and bi-polar technology is used in manufacturing this device.

IC2 input pin 15 monitors the comparator output from pin 10 of IC1 while output pins 1 and 19 provide high or low logic signals (to pins 8 and 9 of IC1) for controlling the Internal Logic Switch of Analog Processor, IC1.

Display circuit board assembly A-11893 has 4 L.E.D. display digits for a maximum reading of 1999. Assembly A-11893-100 has 5 digits for a maximum display of 19999. The digital indicator may be converted from a 4-digit to a 5-digit display by soldering DSP-1 (B-C Part Number: E17-33) in place and modifying the main digital indicator board according to Range Selection Table 3.

On the Display circuit board assembly, digit enable transistors Q1 through Q5 are controlled by five Digit Enable output lines from Digital Processor, IC2. Individual digit segments are controlled by the 7-segment Driver output lines.

Resistor,R1 (22Ω) may be added to the Display circuit board to provide an optional decimal point.

Decimal Point Location	R1 Position
None	Omit
Between DSP-4 and DSP-3	1 to A
Between DSP-3 and DSP-2	1 to B

FIGURE 2. A-11892-XXX DIGITAL INDICATOR SCHEMATIC

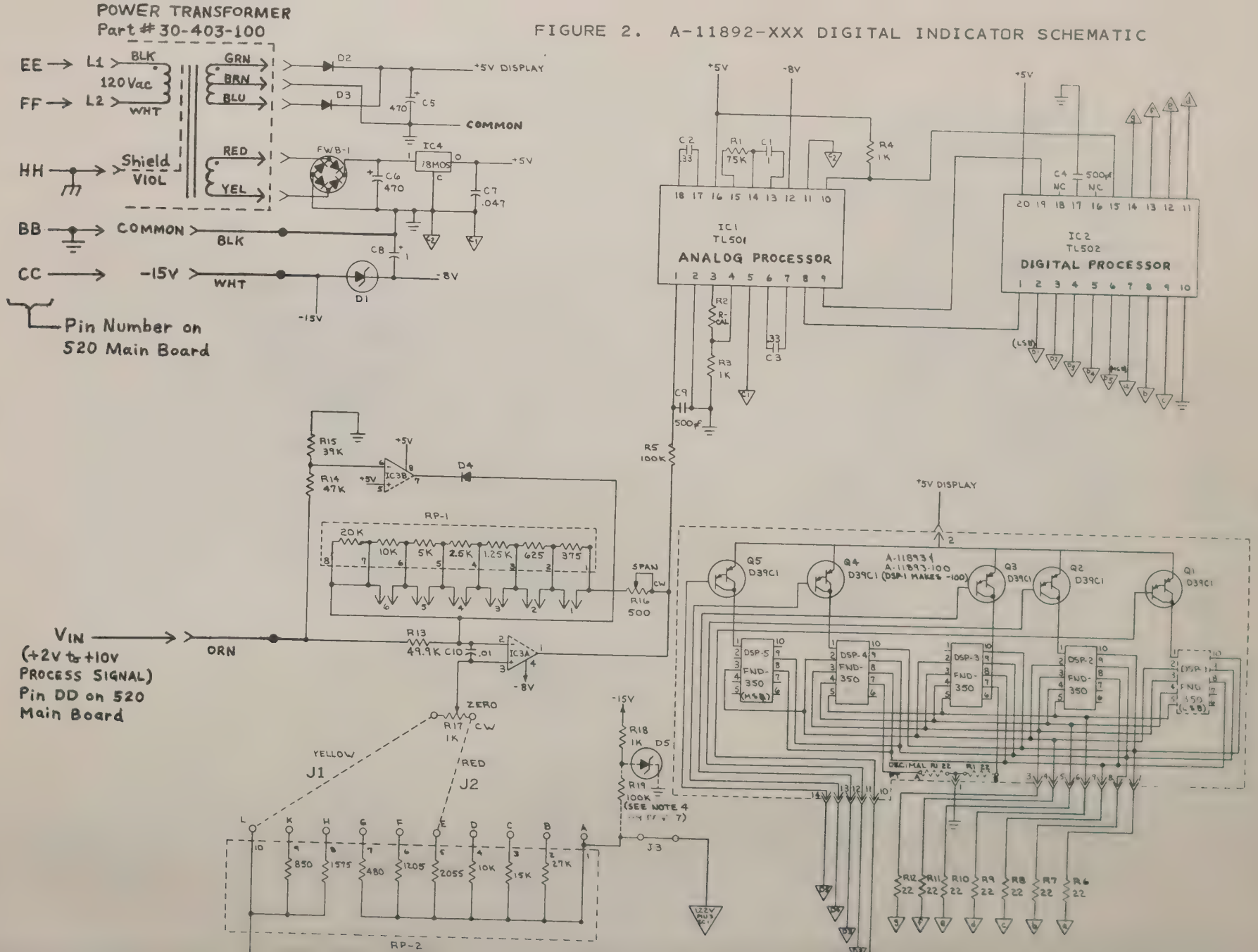
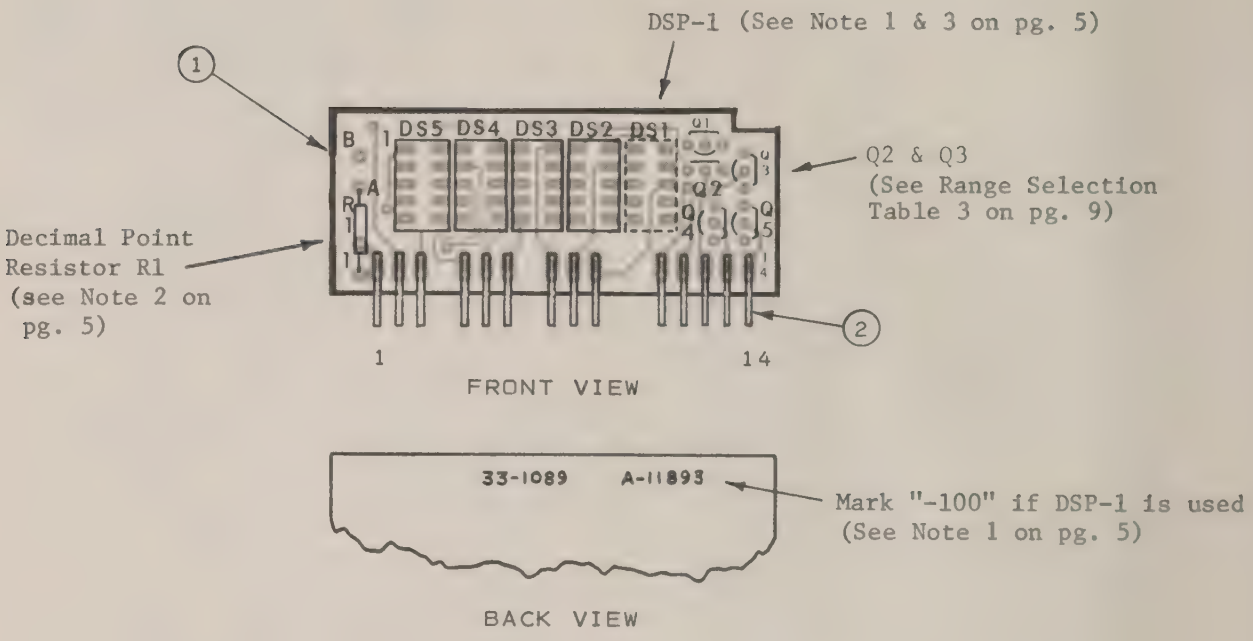
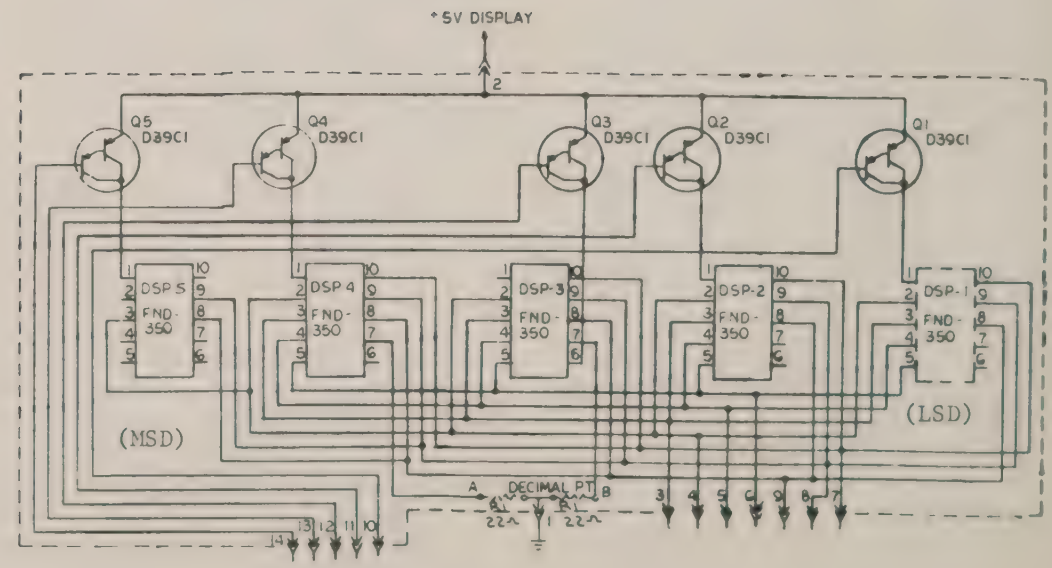


FIGURE 3. LED DISPLAY CIRCUIT BOARD, A-11893-XXX, AND SCHEMATIC





Connects To Digital Indicator
Main Board, A-11892-XXX

TABLE 1. DIGITAL INDICATOR ASSEMBLIES

DIGITAL INDICATOR ASSEMBLY NUMBER	DIGIT DISPLAY BOARD ASSEMBLY NUMBER
A-11892-000	A-11893, 4-DIGIT P.C.B. ASSEMBLY
A-11892-100	A-11893-100, 5-DIGIT P.C.B. ASSEMBLY (NOTE #1)

PARTS LIST FOR DISPLAY CIRCUIT BOARD, A-11893-XXX:

ITEM	PART NUMBER	DESCRIPTION
DSP-1	E17-33	L.E.D.,NUMERIC DISPLAY, FND 350 (ADD DSP-1 TO MAKE 5-DIGIT DISPLAY BOARD, A-11893-100. SEE NOTE #1).
DSP-2	E17-33	L.E.D.,NUMERIC DISPLAY, FND 350
DSP-3	E17-33	L.E.D., NUMERIC DISPLAY, FND 350
DSP-4	E17-33	L.E.D., NUMERIC DISPLAY, FND 350
DSP-5	E17-33	L.E.D., NUMERIC DISPLAY, FND 350
Q1-Q5	E20-61	TRANSISTOR, SILICON, PNP, DARLINGTON D39C-1
R1	E19-35-34	22Ω, ¼W, ±10%, CARBON (SEE NOTE #2)
(1)	33-1089	P.C.B.
(2)	34-881-1	"F" POST (14 REQUIRED)

NOTES FOR DISPLAY CIRCUIT BOARD, A-11893-XXX:

1. To make a 5-digit Display Board (A-11893-100), Item DSP-1 should be soldered in place and "-100" added to assembly number.
2. Decimal Point position may be selected by adding Resistor R1 (22Ω, ±10%, ¼W) as follows:

   For Decimal Point between DSP-4 and DSP-3, solder R1 into holes 1 and A on Digit Display Board.

   For Decimal Point between DSP-3 and DSP-2, solder R1 into holes 1 and B on Digit Display Board.
3. Mounting holes for LED Display Digit, DSP-1, are not solder filled.
4. All LED Display Digits should have the same brightness code. Code number (05, 06, 07, etc.) is located on right side of digit package.

FIGURE 4. DIGITAL INDICATOR ASSEMBLY, A-11892-XXX

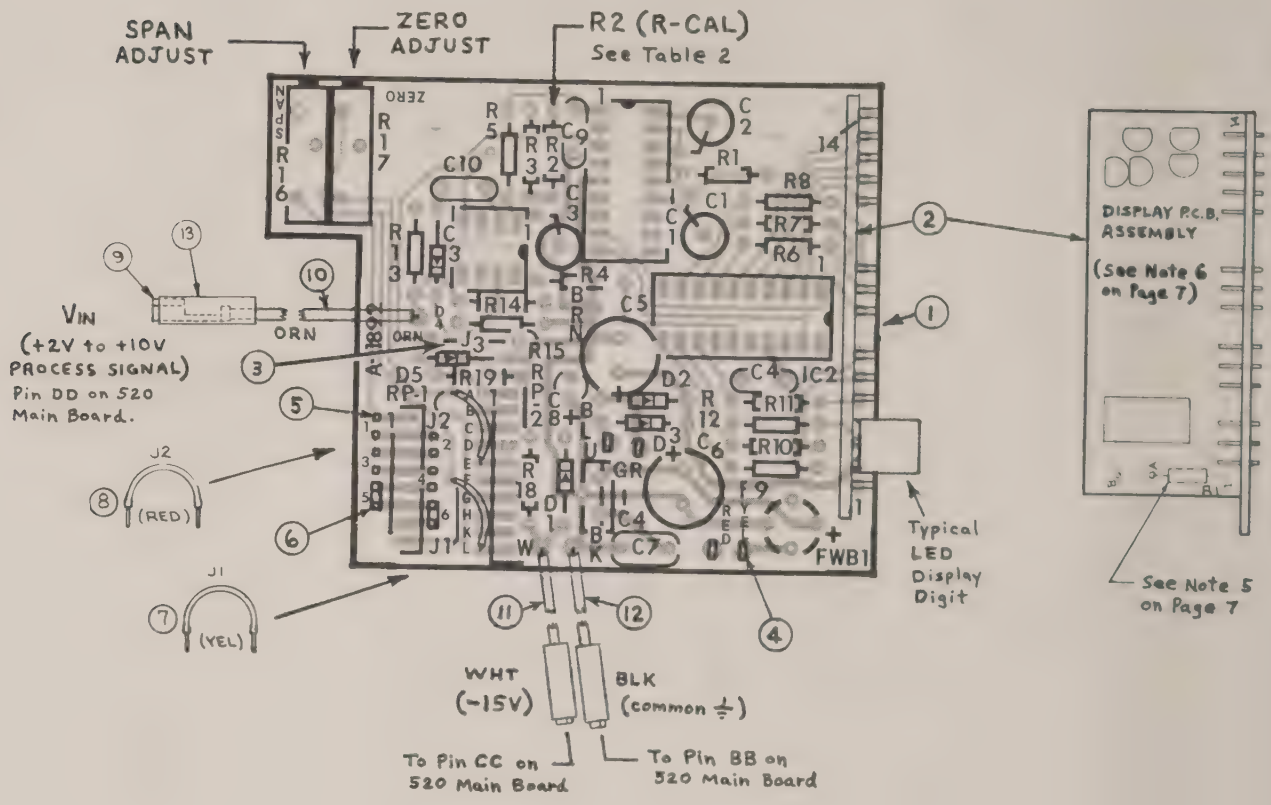


TABLE 2. DETERMINING R2 (R-CAL)
(See Note 7 on pg. 7)

R2 (R-CAL)		REF. SOURCE VOLTAGE (IC1, PIN 3 TO ⏚)
PART NUMBER	DESCRIPTION	
CYZR-788-058	130Ω, 1/8W, ±1%, MF	+1.1200 to 1.1400
CYZR-837-200	150Ω, 1/8W, ±1%, MF	+1.1401 to 1.1600
E19-24-123	169Ω, 1/8W, ±1%, MF	+1.1601 to 1.1800
CYZR-862-128	191Ω, 1/4W, ±1%, MF	+1.1801 to 1.2000
CYZR-862-132	210Ω, 1/4W, ±1%, MF	+1.2201 to 1.2200
CYZR-837-948	237Ω, 1/8W, ±1%, MF	+1.2201 to 1.2400
E19-24-139	249Ω, 1/8W, ±1%, MF	+1.2401 to 1.2600
CYZR-722-10	267Ω, 1/4W, ±1%, MF	+1.2601 to 1.2800
CYZR-868-004	294Ω, 1/8W, ±1%, MF	+1.2801 to 1.3000
CYZR-864-147	301Ω, 1/8W, ±.5%, MF	+1.3001 to 1.3200

NOTES FOR DIGITAL INDICATOR ASSEMBLY, A-11892-XXX:

1. Jumper J1 (Yellow wire) is soldered to 'L' and J2 (Red wire) is soldered to 'E'. Both jumpers may be repositioned as required per Range Selection Table 3 (Pg. 9).

2. Jumper J3 (Bare wire) is soldered in place but may be omitted as required per Range Selection Table 3.

3. Shorting Block Jumpers may be added or relocated as required per Range Selection Table 3. If additional Block Jumpers are needed, order B-C No. 71-045 (package of 2 Block Jumpers, 34-923).

4. D5 and R19 to be inserted as required per Range Selection Table 3.

5. Decimal Point position (optional) may be selected by adding Resistor R1 (22Ω, ±10%, ¼W) as follows:

   For Decimal Point between DSP-4 and DSP-3, solder R1 into holes 1 and A on Digit Display Board.

   For Decimal Point between DSP-3 and DSP-2, Solder R1 into holes 1 and B on Digit Display Board.

6. To make a 5-digit Display Board (A-11893-100), Item DSP-1 should be soldered in place and "-100" added to assembly number.

7. The value of Resistor R2 (R-CAL) is selected to provide a +1.000 V reference V_{REF} (at pin 4 of IC1) for Dual-Slope Integration. The value for R2 varies with the source voltage measured at pin 3 of IC1.

   Source voltage is measured and the correct value for R2 (R-CAL) is soldered in place at the factory. Selection of R2 (R-CAL) is not part of the field calibration procedure and need not be changed unless IC1 is replaced.

PARTS LIST FOR DIGITAL INDICATOR MAIN BOARD ASSEMBLY, A-11892-XXX

ITEM	PART NUMBER	DESCRIPTION	QUANTITY
C1	39-455	1µF, ±10%, 50 WVDC, METALLIZED POLYCARBONATE	
C2,C3	39-451	.33µF, ±20%, 50 WVDC, METALLIZED MYLAR	
C4	39-387	500 pF, ±20%, 100 WVDC, CERAMIC	
C5,C6	E13-93	70µF, -10%, +100%, 16 WVDC, ALUMINUM ELECT.	
C7	39-325	.047µF, ±10%, 100 WVDC, MYLAR	
C8	39-382	1µF, ±20%, 35 WVDC, TANT.	
C9	39-387	500 pF, ±20%, 100 WVDC, CERAMIC	
C10	39-311	.01µF, +80%, -20%, 50 WVDC, CERAMIC	
D1	E20-18	6.2V, ±5%, ZENER DIODE, IN753A, 400 mW	
D2,D3	37-66	SILICON DIODE, IN4005, PIV 500, If = 1A	
D4	EYZP-384	SILICON DIODE, SG3087, PIV 250, If = 100 mA	
D5	E20-128	6.4V, ±5%, TEMP. COMP., ZENER DIODE, IN4577, 400 mW (SEE NOTE #4, PG. 7)	
FWB1	37-182	FULL WAVE BRIDGE, W-113	
IC1	E21-182	I.C., A/D CONVERTER, TL501	
IC2	E21-183	I.C., LOGIC CONTROLLER, TL502	
IC3	31-1015	I.C., DUAL OP AMP, SA1458V	
IC4	E21-171	I.C., VOLTAGE REGULATOR, µA78M050C	
R1	CYZR-932-065	75K, ±1%, 1/8W, MF	
R2	---	(R-CAL) SEE TABLE 2 (PG. 6) AND NOTE 7 (PG. 7)	
R3	E19-24-201	1K, 1%, 1/8W, MF	
R4	CYZR-481	1K, ±10%, 1/4W, CARBON	
R5	40-1314	100K, ±10%, 1/4W, CARBON	
R6-R12	E19-35-34	22Ω, ±10%, 1/4W, CARBON	
R13	CYZR-861-368	49.9K, ±1%, 1/8W, MF	
R14	40-1847	47K, ±10%, 1/4W, CARBON	
R15	40-1845	39K, ±10%, 1/4W, CARBON	
R16	E19-220	500Ω, ±10%, 3/4W, 25 TURN POT	
R17	E19-221	1K, ±10%, 3/4W, 25T, POT	
R18	CYZR-481	1K, ±10%, 1/4W, CARBON	
R19	CYZR-788-023	100K, ±1%, 1/8W, MF, (SEE NOTE #4, PG. 7)	
RP-1	40-2044	RESISTOR PACKAGE, 8-PIN	
RP-2	40-2045	RESISTOR PACKAGE, 10-PIN	
①	33-1090	P.C.B. (DIGITAL PROCESS METER)	1
②	A-11893-XXX	DISPLAY ASSEMBLY (SEE TABLE 1, PG. 5)	1 (NOTE 6, PG. 7)
③	47-414	INSERTABLE BARE WIRE JUMPER	1 (NOTE 2, PG. 7)
④	34-847	MOD 1 PIN	5
⑤	34-904	MOD 2 PIN	12
⑥	34-923	SHORTING BLOCK JUMPER	AS REQ'D (NOTE 3, PG. 7)
⑦	47-4026	22 AWG, YELLOW WIRE, L = 2"	1 (NOTE 1, PG. 7)
⑧	47-4025	22 AWG, RED WIRE, L = 2"	1 (NOTE 1, PG. 7)
⑨	34-861	MOD 1 RECEPTACLE	3
⑩	47-4079	22 AWG, ORANGE WIRE, L = 5"	1
⑪	47-4027	22 AWG, WHITE WIRE, L= 8"	1
⑫	47-4027	22 AWG, BLACK WIRE, L = 8"	1
⑬	R4-72	SLEEVING 3/4" LONG	3

TABLE 3. RANGE SELECTION

RANGE (NOTE 1)	J1 YELLOW	J2 RED	J3 BARE WIRE (NOTE 2)	BLOCK JUMPER(S) REQUIRED (ITEM #6)	R19 (NOTE 3)	D5 (NOTE 3)	R1 POSITION FOR DECIMAL POINT (NOTE 4)	DPM MAIN BOARD (NOTE 5)	DSP-1 LED DISPLAY DIGIT (NOTE 6)	DISPLAY BOARD TRANSISTORS (NOTE 7) Q2	Q3	COMMENTS
-400 TO 0	K	F		4,5,6								
-300 TO 0	L	E		2,4,5,6								
-200 TO 0	L	E		3,4,5,6								
-100 TO 0	L	E		2,3,4,5,6,								
5 TO 0	K	F		2,3,5,6,			HOLES 1 & A			CLIP		DISPLAYS 5.0
0 TO 10	L	E		3,4,6,			HOLES 1 & A			CLIP		DISPLAYS 10.0
0 TO 50	L	E		2,3,5,6,			HOLES 1 & A					DISPLAYS 50.0
0 TO 100	L	E		3,4,6,						CLIP		
0 TO 200	L	E		4,5,						CLIP		
0 TO 300	L	E		2,4,5,6,								
0 TO 400	L	E		4,5,6,								
0 TO 500	L	E		2,3,5,6,								
0 TO 600	L	E		3,5,6,								
0 TO 700	L	E		2,5,6,								
0 TO 800	L	E		5,6,								
0 TO 900	L	E		2,3,4,6,								
0 TO 1000	L	E		3,4,6,								
0 TO 1200	L	E		4,6,								
0 TO 1400	L	E		3,6,								
0 TO 1600	L	E		6								
0 TO 1800	L	E		3,4,5,								
0 TO 2000	K	F		4,5								
0 TO 2500	K	B		1,2,4,5,6,				A-11892-100	ADD			
0 TO 3000	K	B		2,4,5,6,				A-11892-100	ADD			
0 TO 4000	H	B		4,5,6				A-11892-100	ADD			
0 TO 5000	K	D		2,3,5,6,				A-11892-100	ADD			
0 TO 10000	H	D		3,4,6,				A-11892-100	ADD			
200 TO 800	L	C	OUT	3,5,6,	JUMPER	IN						
300 TO 1200	L	E		3,4,6,								
500 TO 1500	L	C	OUT	3,4,6,	JUMPER	IN						
1300 TO 2300	K	B	OUT	3,4,6,	IN	IN		A-11892-100	ADD			
2000 TO 4000	H	B	OUT	4,5,	IN	IN		A-11892-100	ADD			

NOTES FOR RANGE SELECTION TABLE 3:

1. Range polarity is positive (+XXX to +XXX) unless shown otherwise.
2. Jumper J3 (Bare Wire) is soldered in place unless specified otherwise.
3. R19 and D5 are OMITTED unless specified otherwise. If a JUMPER is specified for R19, use Bare Wire (47-414) as required.
4. Decimal Point Resistor R1 is NOT USED unless specified otherwise. Decimal Point position may be selected by adding Resistor R1 (22Ω, ±10%, ¼W) as follows:

   For Decimal Point between DSP-4 and DSP-3, solder R1 into holes 1 and A on Digit Display Board.

   For Decimal Point between DSP-3 and DSP-2, solder R1 into holes 1 and B on Digit Display Board.
5. DPM Main circuit board A-11892-000 is used unless specified otherwise. A-11892-000 is a 4-digit DPM and A-11892-100 is a 5-digit DPM.
6. Display LED, DSP-1, is NOT REQUIRED unless specified otherwise. Adding DSP-1 will provide a 5-digit Display.
7. Digit enable transistors **Q2** and **Q3** are REQUIRED on Display circuit board A-11893. Clip-Out component only when specified.

DIGITAL INDICATOR KITS

DPM Kit Part Number	Description
71-607-1	4-Digit Indicator Kit (A-11892-000-1 DPM)
71-608-1	5-Digit Indicator Kit (A-11892-100-1 DPM)

Literature bulletin 1252/IN 60-1 describes the 4-Digit DPM Kit (71-607-1); and 1252/IN 61-1 describes the 5-Digit DPM Kit (71-608-1).

Replacement Digital Indicator assemblies are available in Kit form only. The A-11892-XXX-1 Indicator in each kit has been pre-tested and burned-in at the factory. The "-1" indicates assembly has been burned-in.

Customer must set-up Digital Indicator (as described in Range Selection Table 3) and calibrate DPM to his process range (see Field Calibration Procedure below).

FIELD CALIBRATION PROCEDURE

The following equipment is required for Calibration:

- Input mV Source (Barber-Colman PA Series Portable Potentiometer or equivalent).
- Extender Assembly (Part No. 24-2 for Models 521,2,3,4; or Part No. 24-3 for High Power Models 525,6,7,8).
- Range Code Calibration Table SPXX-X XXXX-XXX (SP15 or SP06 for Analog Setpoint and SP14 or SP05 for Digital Setpoint).

Proceed as follows:

1. Shorting Block jumpers (1 through 6), soldered wire jumpers (J1, J2, and J3), and selected components (D5 and R19) must be added or omitted as described in Range Selection Table 3 (see page 9) before performing the Calibration Procedure.

   Note: For ranges not listed, consult factory for correct jumper and component arrangement.

2. Connect the d-c millivolt input source to rear terminals 1 (+ plus) and 2 (- minus) on the 520 Series controller.

   Note: For thermocouple ranges, use appropriate thermocouple or thermocouple extension leadwire between millivolt source and controller. The NEGATIVE (-) wire is usually coded RED.

3. Remove the 520 Series controller from its housing and insert the proper Extender Assembly. Plug controller into Extender Assembly.
4. Turn power ON to controller.
5. Set the d-c millivolt source for the equivalent of about 20% of the Range temperature (observe cold-junction mV compensation procedure). Select this point from the Range Code Calibration Table, SPXX-X XXXX-XXX.
6. Adjust ZERO potentiometer R17 until the LED display indicates the equivalent DPM Reading ±1 digit (from the Range Code Calibration Table) for the temperature selected in step 5.
7. Set the d-c millivolt source for the equivalent of about 80% of the Range temperature (observe cold-junction mV compensation procedure). Select this point from the Range Calibration Table.
8. Adjust SPAN potentiometer R16 until the LED display indicates the equivalent DPM Reading ±1 digit (from the Range Code Calibration Table) for the temperature selected in step 7.
9. Interaction between ZERO and SPAN adjustments may occur. Repeat steps 5, 6,7, and 8 until desired accuracy is achieved and further adjustment is not required.
10. Seal ZERO (R17) and SPAN (R16) potentiometers.

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4.3 Isolation Board Calibration (Setpoint Options 2, 3, 5, 6, 7, or 8)

Calibration may be performed with Isolation Board plugged into Main Board (connector P6) and jumpers JA, JB, JC, JD, and JE on Main Board clipped.

1. Calibrate +15 Vdc Isolated Supply

a. Connect an accurate digital voltmeter (DVM such as Fluke or Hewlett Packard) to pin 7 (+V) and pin 11 (common) of connector P6.

b. Adjust potentiometer R13 on Isolation Board for +15 Vdc, ±0.1% (14.985 Vdc to 15.015 Vdc).

2. Check −5.1 Vdc Supply

Place DVM leads on pin 4 (−V) and pin 11 (common) of connector P6. Voltage should be −5.1 Vdc, ±5% (−4.845 Vdc to −5.355 Vdc). If voltage is out of this range, zener diode D8 may be defective.

3. Calibrate Input/Output Signal Tracking

a. Attach a clip-on shorting jumper from pin 11 to pin 14 (Isolation Board connector, P6) and connect DVM leads to pin 1 and pin 5 of connector P6.

b. Using a PORTABLE POT or other suitable mV source, adjust the input signal to mid-span of controller's process range (see bulletin 1111/DB 10 for temperature–mV tables).

c. Observe offset mV reading measured on DVM and then vary input signal from PORTABLE POT throughout controller's process range (see bulletin 1111/DB 10 for temperature–mV tables).

d. Adjust potentiometer R1 on Isolation Board to obtain a minimum change in offset mV over the full process span.

Input/Output signal tracking (pin 1 to pin 5 of P6) on Isolation Board should be within 0.1% of process output span. Example: Process Output Range = 2V to 10V; Process Output Span = 8V = 8000 mV. Therefore, 0.1% = 8 mV.

Tracking may not occur at 0 Vdc offset. Tracking above 40 mV offset may indicate a D1-D2 mismatch, or a bad isolation transformer, T1.

4. Re-calibration of Main Board Adjustments

a. After calibrating the +15V isolated supply and input/output isolator tracking, Process Output and Deviation Output on Main Board should be re-calibrated.

b. To calibrate Process Output, disconnect clip-on jumper installed in Step 3a. and place DVM leads on pin 1 and pin 14 of connector P6.

c. Set input signal mV source (PORTABLE POT) for mid-span of controller's process range.

d. Adjust potentiometer R8 on Main Board for a Process Output of 6 Vdc, ±1% (5.940 Vdc to 6.060 Vdc).

e. To calibrate Deviation Output on Main Board, place the front-panel SETPOINT control at mid-span of instrument range.

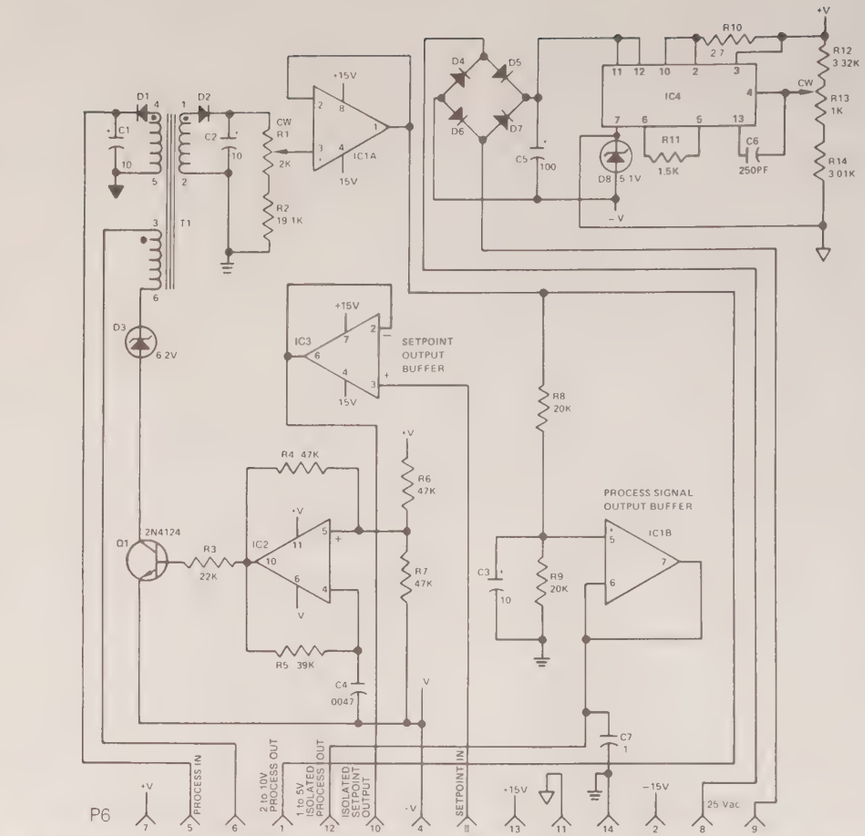
f. Connect DVM leads to pin 1 (Deviation) and pin 7 (ground) of Main Board connector P5.

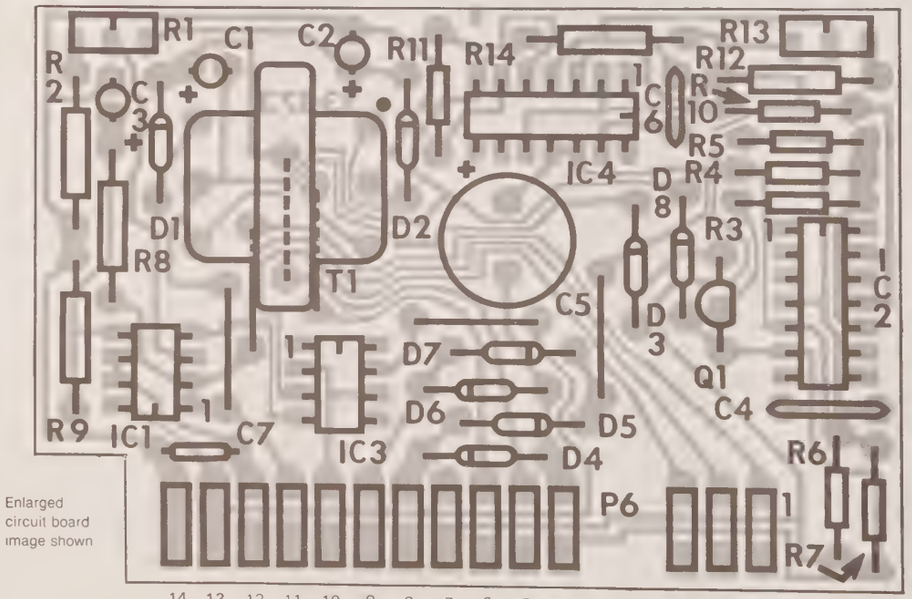
g. Adjust potentiometer R8 on Main Board for a Deviation voltage of 0 Vdc, ±0.025 Vdc.

h. Lastly, perform the Meter Span adjustment described in Section 3 of Instruction Manual.

Table 4-2. Isolation Board A-11121-1, Parts List

Symbol	Part Number	Description
		CAPACITORS
C1,2,3	39-400	10uF, ±20%, 15 WVDC, Tantalum
C4	39-466	.0047uF, ±10%, 50 WVDC, Polycarbonate
C5	39-163	100uF, +100 −10%, 50 WVDC, Electrolytic
C6	39-076	250pF, ±20%, 500 WVDC, Ceramic
C7	CYZR-803	.1uF, ±20%, 250 WVDC, Mylar
		DIODES
D1,2	A-10057	60 PIV, I_f = 100 mA, Matched Threshold
D3	37-179	6.2V Zener, ±5%, 400 mW
D4,5,6,7	EYZP-384	250 PIV, I_f = 100 mA, Silicon Diode
D8	37-162	5.1V Zener, ±5%, 400 mW
		INTEGRATED CIRCUITS
IC1	31-1015	Dual 741 Minidip Op Amp
IC2	31-1002	709 Op Amp
IC3	31-1012	741C Minidip Op Amp
IC4	31-1010	723C Voltage Regulator
		TRANSISTOR
Q1	EYZP-632	2N4124 NPN Silicon
		RESISTORS
		Resistors are ±10% tolerance, 1/4W, unless stated otherwise.
R1	29-377	2k, ±20%, 1/2W, Potentiometer
R2	E19-29-328	19.1k, ±.5%, 1/8W
R3	40-1950	22k
R4,6,7	40-1847	47k
R5	40-1845	39k
R8,9	CYZR-864-330	20k, ±.5%, 1/8W
R10	E19-35-943	2.7 ohms
R11	CYZR-861-218	1.5k, ±1%, 1/8W
R12	CYZR-864-251	3.32k, ±.5%, 1/8W
R13	29-418	1k, ±20%, 1/2W, Potentiometer
R14	CYZR-864-247	3.01k, ±.5%, 1/8W
		TRANSFORMER
T1	30-319-1	Modulator





Enlarged circuit board image shown

BOARD CONNECTOR NUMBERS — P6 PLUGS INTO MAIN BOARD

Figure 4-1. Isolation Board A-11121-1 and Schematic

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F-16198-2 BK FEBRUARY 1980

LITHO IN U.S.A.

Series 520
Troubleshooting Main Board and Range Boards, Changing Ranges

5. TROUBLESHOOTING

5.1 General

All of the Controller, except the preamplifier stage of IC1, can be troubleshot with a VOM of 20,000 ohms/volt sensitivity. Do not attempt to make major repairs on the Main Board. Minor repairs such as replacing broken pins may be made. Recalibrate the Main Board if you replace any critical component on it.

When making repairs on printed circuit boards or soldering transistor or integrated circuit terminals, use a 35 watt or less soldering iron and 63/37 or 60/40 resin core solder.

Following is a list of instruments for field troubleshooting the Controller.

Oscilloscope with calibrated sweep or equivalent (required to check waveforms).

Accurate DC Voltmeter

Strip Chart Recorder

In any general troubleshooting procedure, always do paragraph 5.2 first.

5.2 Power Supply Board

Measure all voltage outputs. If any part is replaced the controller must be completely recalibrated.

5.3 Excessive Drift of Either Setpoint or Process Temperature

The drift may be due to thermocouple deterioration. Thermocouple deterioration is usually found in a periodic inspection program. To determine thermocouple deterioration place the test thermocouple as close to the thermocouple under test as possible. If the output of the thermocouple under test differs from what is acceptable by the user (outside his or the manufacturer's specifications) then the thermocouple is defective.

Inspect thermocouple to leadwire and leadwire to controller connections to be certain they are covered properly so that air drafts across them are not affecting temperature indications by causing temperature gradients.

Measure the line voltage. It must be within the specified range.

5.4 Preamplifier IC1 and Range Board

Troubleshooting the Preamplifier stage of IC1 and the Range Board to which it is connected, requires battery operated voltmeters with input impedances of 10M ohms or higher.

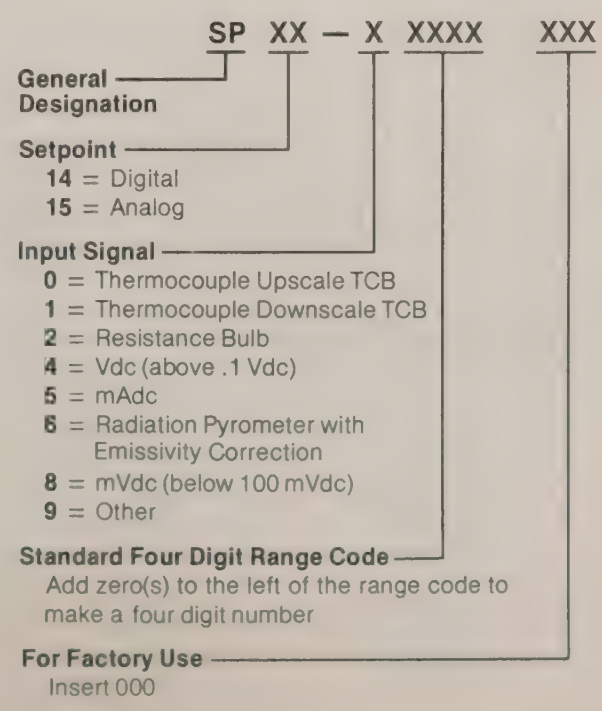
Battery operated test instruments with such an input impedance are the Hewlett-Packard Company Model 427A Multi-Function Meter and the John Fluke Manufacturing Company Model 871AB DC Differential Voltmeter. The remainder of the controller following the DC Amplifier may be troubleshot with a VOM with a 20,000 ohms/volt voltmeter or higher sensitivity.

5.5 Thermocouple Break Check

1. Disconnect any input (TC or dc millivolt source).
2. The Temperature Indicator should go full scale.
3. A milliammeter connected across the current output terminals should indicate zero.

5.6 Range Board Assemblies

Individual components on this assembly should not be replaced. When ordering a complete range board assembly, the following code must be written.


SP XX — X XXXX XXX
General Designation
Setpoint
14 = Digital
15 = Analog
Input Signal
0 = Thermocouple Upscale TCB
1 = Thermocouple Downscale TCB
2 = Resistance Bulb
4 = Vdc (above .1 Vdc)
5 = mAdc
6 = Radiation Pyrometer with Emissivity Correction
8 = mVdc (below 100 mVdc)
9 = Other
Standard Four Digit Range Code
Add zero(s) to the left of the range code to make a four digit number
For Factory Use
Insert 000

STANDARD RANGES FOR DIGITAL SETPOINTS AND FOR ANALOG SETPOINTS WITH SINGLE RANGE TEMPERATURE DIAL DIVISIONS

Thermocouple Ranges

Range	Code Number for Range and Thermocouple Type					
	J	K	R	S	B	Tungsten 5% Rhenium-Tungsten 26% Rhenium*
0–399°F	56					
0–499°F	306					
0–599°F	15					
0–799°F	16					
0–999°F	17	207				
0–1999°F		30	166	316		
0–2999°F			38	36	1814	
2000–3999°F						3382
200–799°F	751					
200–1199°F	203	2411				
500–1499°F	2980	3406				
1300–2299°F		3531				
0–399°C	22					
0–499°C	23					
0–599°C	24	110				
0–799°C		32				
0–999°C		33	276			
0–1999°C					3611	2552
200–1199°C		185	1597	3713		
500–1499°C			521	1395		3719

*No Symbol Positive Wire is Hoskins Alloy 405 Negative Wire is Hoskins Alloy 426

J—Iron Constantan K—Chromel Alumel R—Plat 13%
S—Plat 10% B—Plat 30% Rh/Plat 6% Rh

STANDARD RANGES FOR ANALOG SETPOINTS (°F AND °C) WITH DUAL RANGE TEMPERATURE DIAL DIVISIONS

The temperature range listed in column 1 is marked on the inner scale of the dial.

Thermocouple Ranges

Range	Code Number J
0–800°F	231
200–800°F	3644

RESISTANCE TEMPERATURE DETECTOR (RTD) RANGES

(100 ohm Resistance Bulb)

Range	Code
0 to 100°F	3550
0 to 100°C	4039
0 to 200°C	4119
0 to 400°F	1815
0 to 400°C	4022
0 to 600°F	4173
0 to 800°F	2345
200 to 800°F	4174

Range	Standard Millivolt Ranges–Uncompensated
0–9.99mV	381
0–49.9mV	1054
0–99.9mV	2892
–5 to 0 to + 5mV	1324*

*Available only with Analog Setpoint

STANDARD RANGES FOR ANALOG SETPOINTS WITH SINGLE RANGE TEMPERATURE DIAL DIVISIONS

Cryogenic (Low Temperature) Ranges

Range	J	T	100 RTD PT*
–400°F to 0°F	—	—	4164
–300°F to + 300°F	318	545	—
–100°F to + 100°F	—	—	4169

* The RTD range cards are calibrated for the ranges specified and apply to a 100 ohm (at 0°C) platinum element with a temperature coefficient of .00385 ohm/ohm/°C. Consult factory for other ranges and for sensors with other temperature coefficients.

5.7 Changing Ranges

5.7.1 IDENTICAL RANGES

Changing range boards with identical ranges is very easy. Unplug the old range board and plug in the new range board. The new range board is factory calibrated and no calibration is required.

5.7.2 CHANGING FROM ONE SPAN TO ANOTHER WITHIN THE SAME KIND OF RANGE

For example, suppose a 0–399°F range board is replaced by a 0–599°F range board.The digital setpoint will still be effective but only up to 399°F. The setpoint must be modified. Also, the 6 Vdc Process Signal Adjustment and the 3 Vdc Setpoint Voltage Adjustment on the Main Board must be adjusted. Don't forget that any process meter should be replaced.

5.7.3 CHANGING BOTH SPANS AND KINDS OF RANGES

For example, suppose a 0–399°F range board is replaced by a 0–49.9 mV range board. The digital set-

point must be modified. The 6 Vdc Process Signal Adjustment and the 3 Vdc Setpoint Voltage Adjustment on the Main Board must be adjusted. Any process meter scale must be replaced.

5.8 Setpoint Switch Assemblies

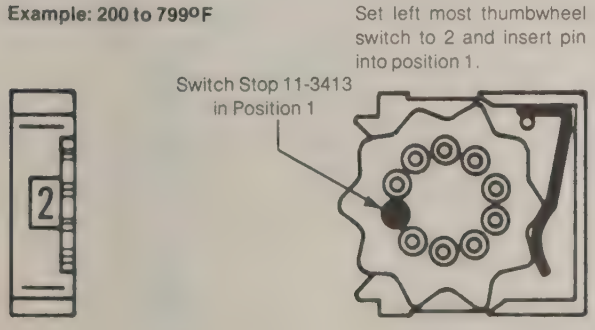
Digits	Part Number	Digital Span
3	A-10342-100	0–X99
3	A-10342-200	200–X99
3	A-10342-300	500–X99
3	A-10342-400	1300–XX99
4	A-10343	0–9999

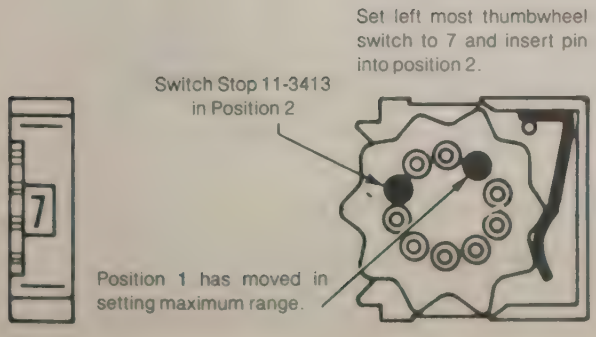
5.9 Modifying a 3-Digit Setpoint Assembly to Change its Range

To install the setpoint assembly, proceed as follows:

1. Hold modules and mounting cover together. Place one of the straps up from the bottom. Place second strap down with the short ends meeting the long ends. Short end should overlap on both sides and snap in place.
2. To set left most thumbwheel switch of the setpoint assembly (hundreds position) to minimum value of the required range, insert switch stop pin (part number 11-3413) into position 1. See example.
3. To set left most thumbwheel switch of the setpoint assembly (hundreds position) to the maximum value of the required range minus one, insert switch stop pin (part number 11-3413) into position 2. See example. Pins are not required for the ranges from 0 to 999.

Example: 200 to 799°F



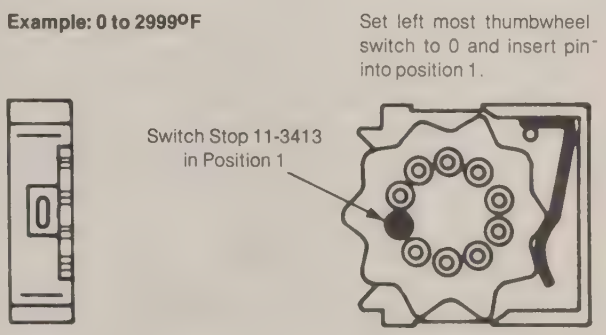

Set left most thumbwheel switch to 7 and insert pin into position 2.
Switch Stop 11-3413 in Position 2
Position 1 has moved in setting maximum range.
7

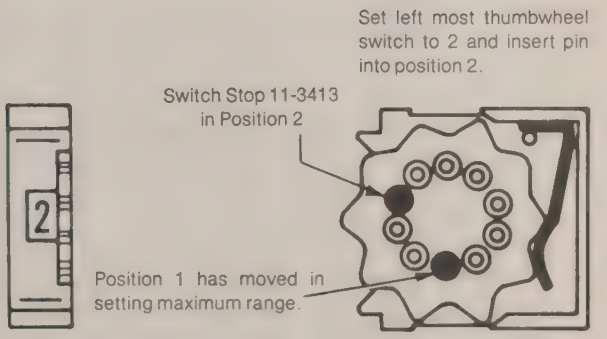
5.10 Modifying a 4-Digit Setpoint Assembly to Change its Range

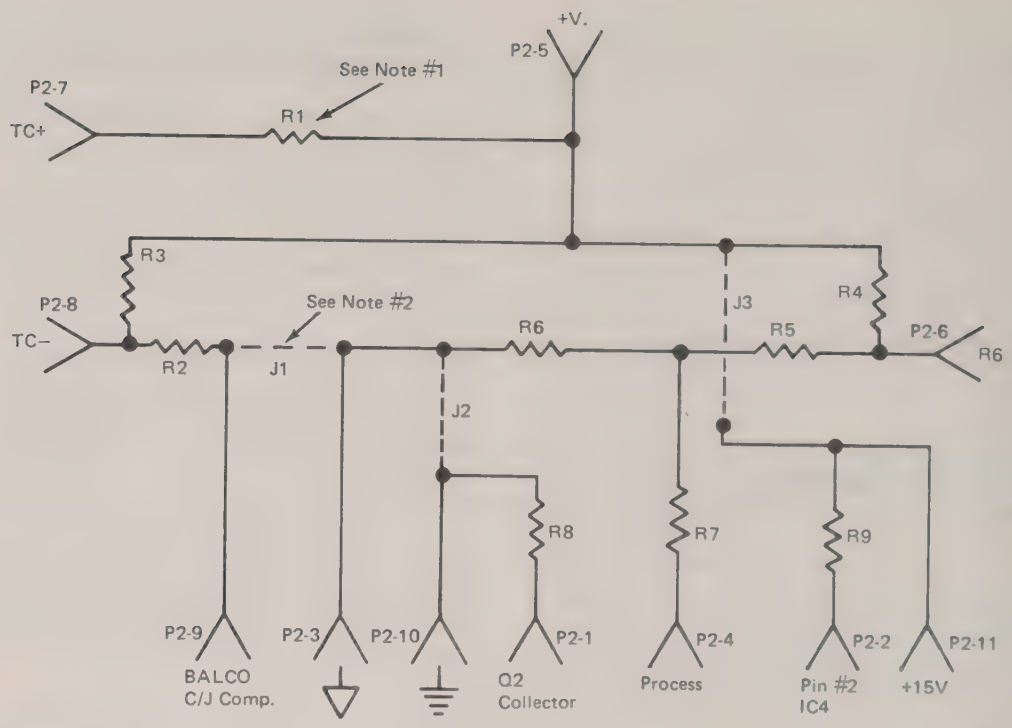
To install the setpoint assembly, proceed as follows:

1. Hold modules and mounting together. Place one of the straps up from the bottom. Place second strap down with the short ends meeting the long ends. Short end should overlap on both sides and snap in place.
2. To set left most thumbwheel switch of the setpoint assembly (thousands position) to the minimum value of the required range, insert switch stop pin (part number 11-3413) into position 1. See example.
3. To set left most thumbwheel switch of the setpoint assembly (thousands position) to the maximum value of the required range minus one, insert switch stop pin (part number 11-3413) into position 2. See example.

Example: 0 to 2999°F



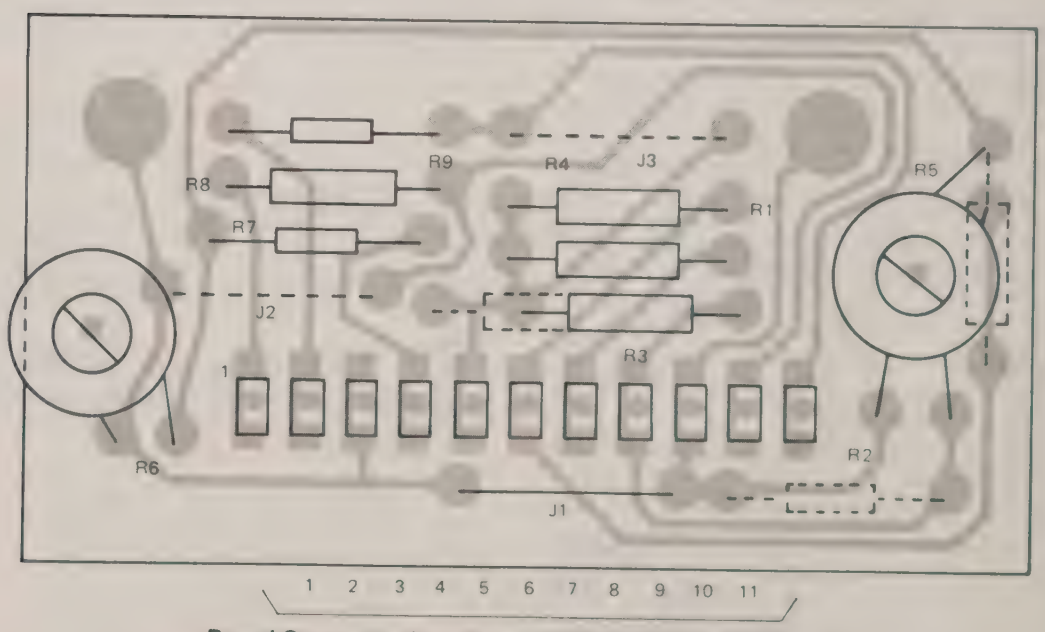

Set left most thumbwheel switch to 2 and insert pin into position 2.
Switch Stop 11-3413 in Position 2
Position 1 has moved in setting maximum range.
2



Notes

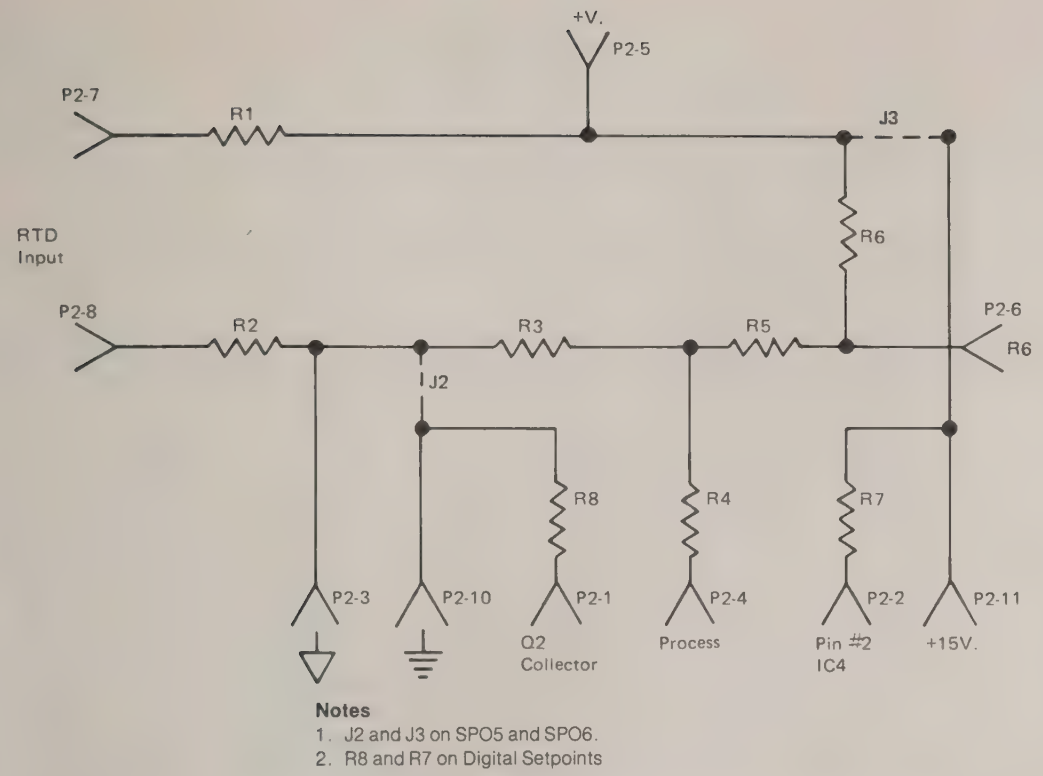
1. R1 is omitted for downscale TCB.
2. J1 is inserted for mV and Type B T/C ranges only.
3. J2 and J3 on SP05 and SP06.
4. R8 and R9 on Digital Setpoints.

R1 is the standard thermocouple break protection resistor. Resistors R2 and R5 set the required millivolt suppression to achieve the 2 to 10 Vdc process signal. R3 determines the current for the cold junction compensation by R2 on the Main Board. R6 and R7 are the preamplifier gain resistors. Resistors R8 and R9 are for span and suppression of the setpoint, respectively.



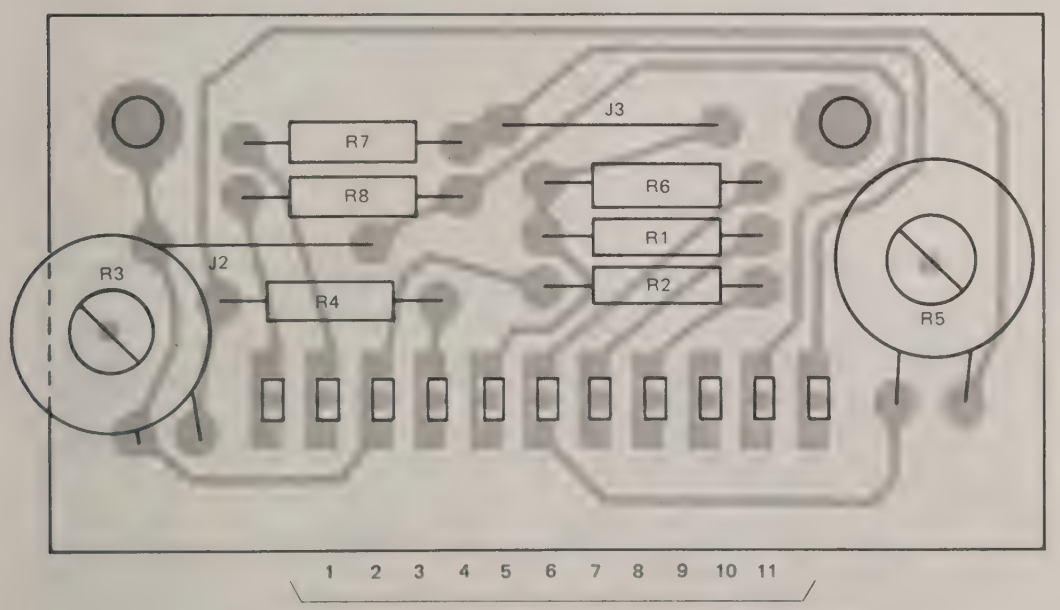
Board Connector Numbers—P2 Plugs Into Main Board

Figure 5-1. Thermocouple and Millivolt Range Board and Schematic



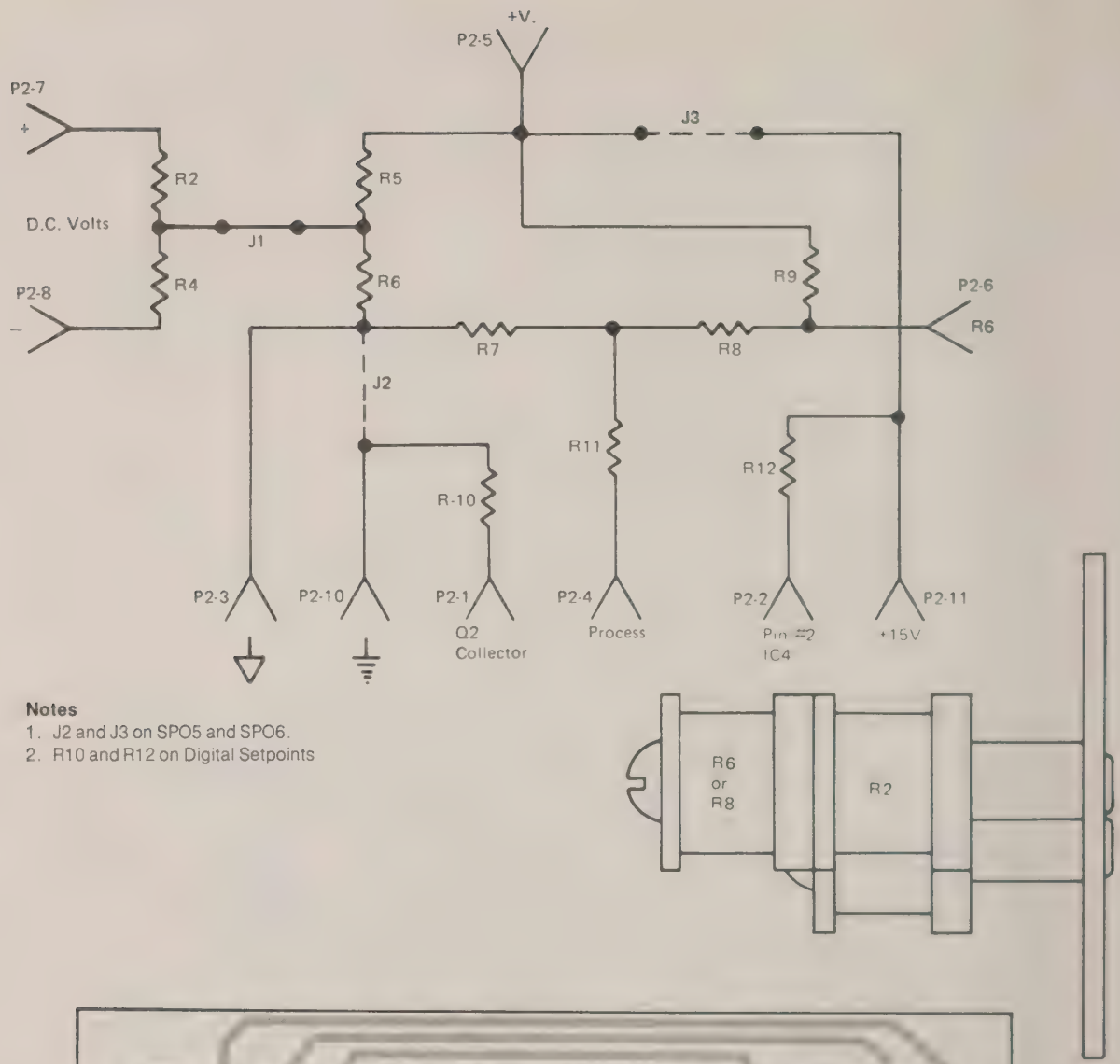
Notes

1. J2 and J3 on SPO5 and SPO6.
2. R8 and R7 on Digital Setpoints



Board Connector Numbers—P2 Plugs Into Main Board

Figure 5-2. Resistance Temperature Detector (RTD) Range Board and Schematic

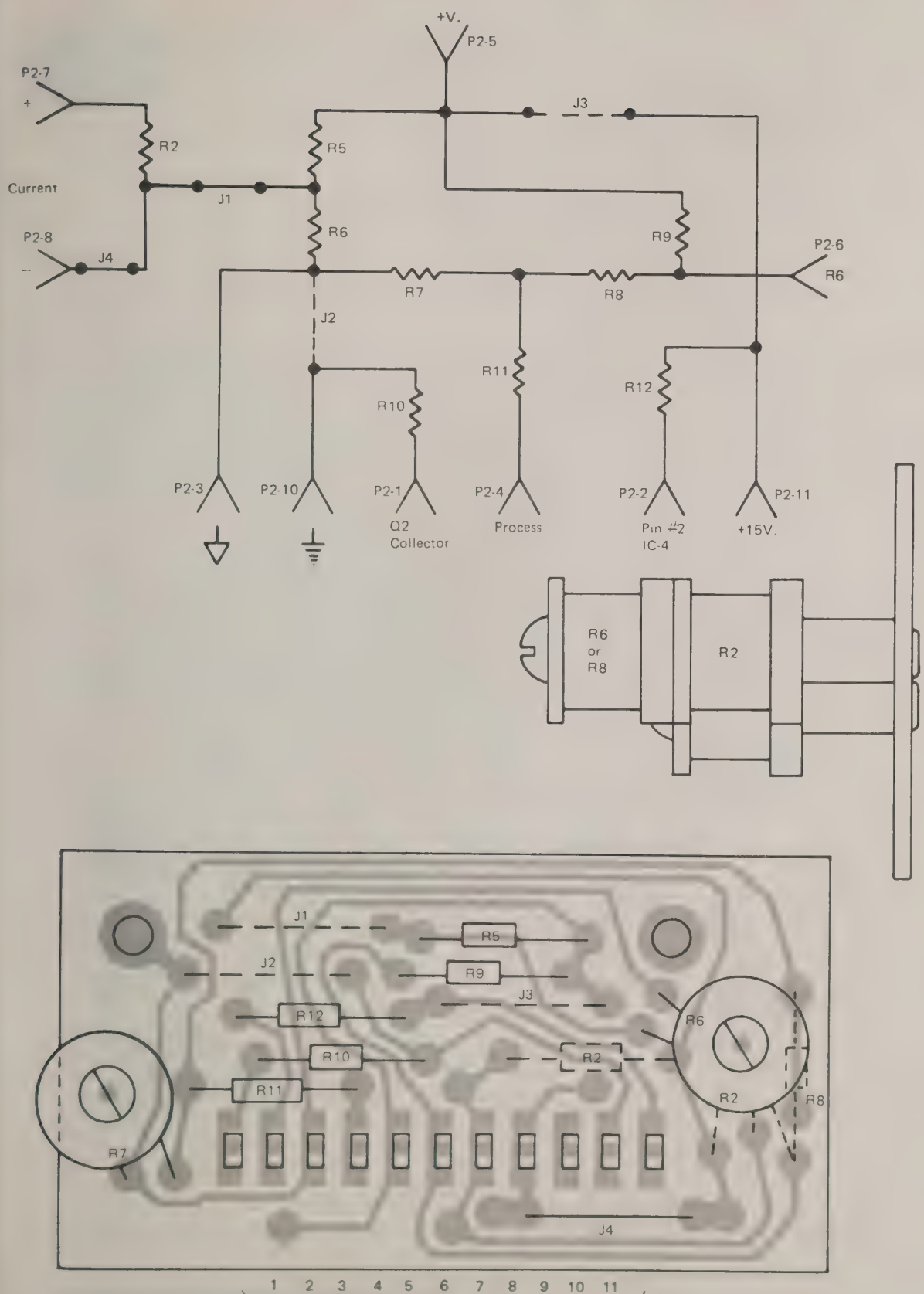


Notes

1. J2 and J3 on SPO5 and SPO6.
2. R10 and R12 on Digital Setpoints

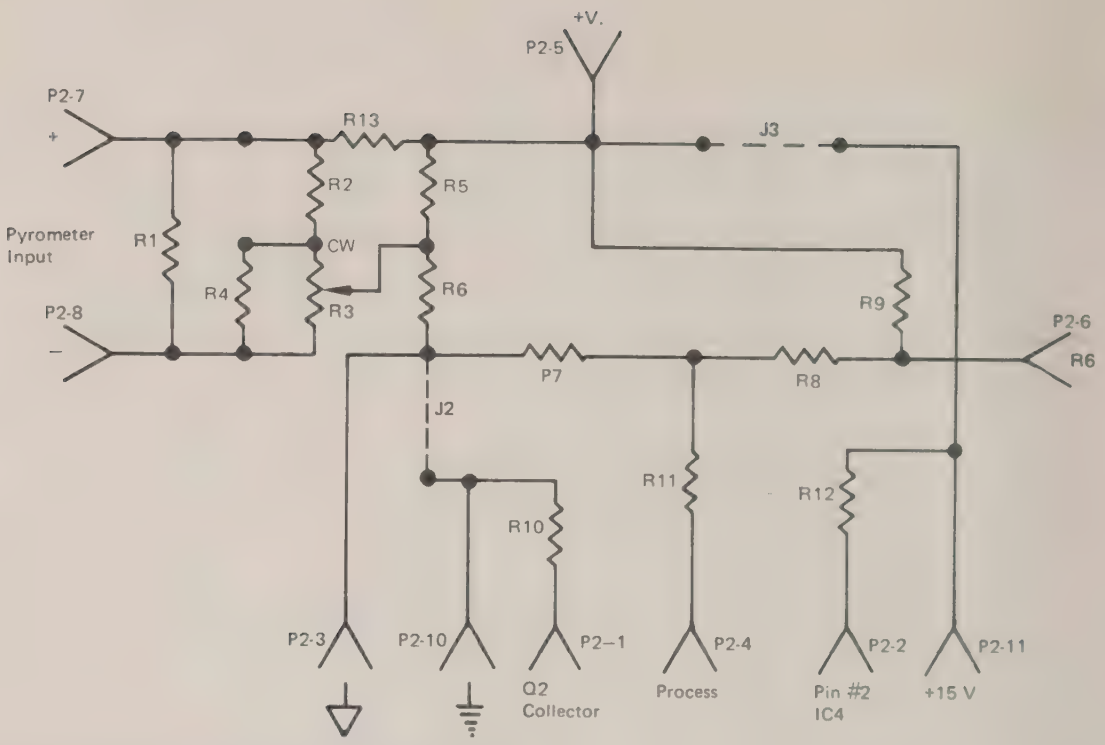
Figure 5-3. Voltage (both above and below .1 Vdc) Range Board and Schematic

Board Connector Numbers—P2 Plugs Into Main Board

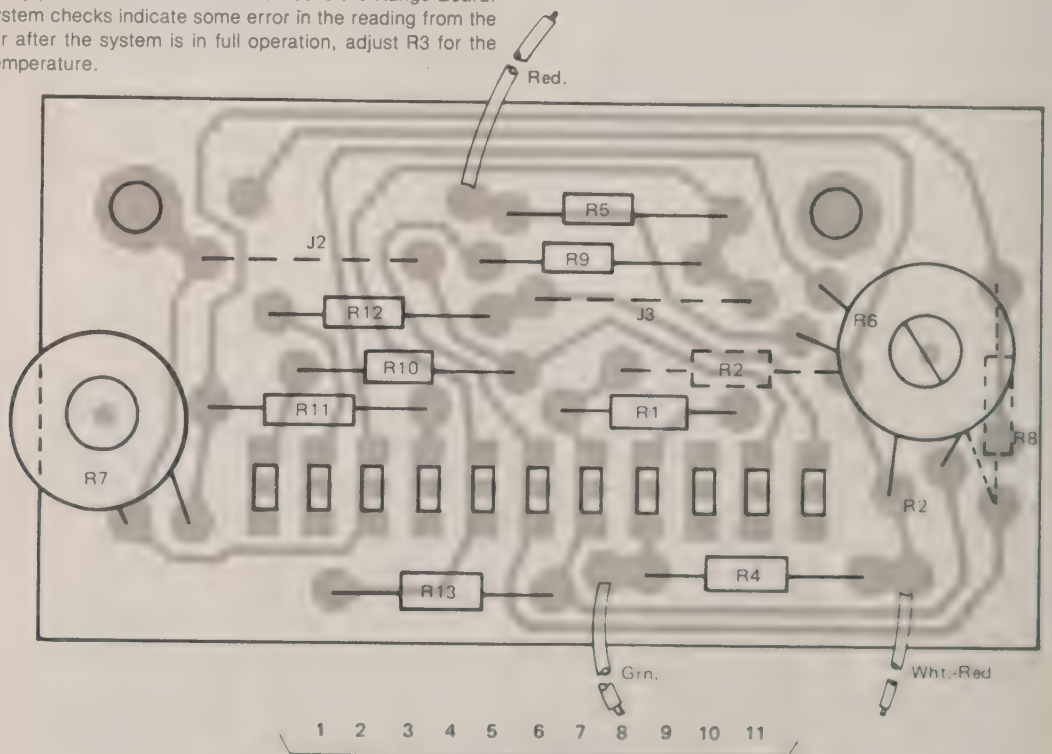


Board Connector Numbers—P2 Plugs Into Main Board

Figure 5-4. Current (mAdc) Range Board and Schematic



To Emissivity potentiometer R3 mounted above the Range Board. Should system checks indicate some error in the reading from the Pyrometer after the system is in full operation, adjust R3 for the correct temperature.



Board Connector Numbers—P2 Plugs Into Main Board

Figure 5-5. Radiation Pyrometer with Emissivity Correction Range Board and Schematic

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INDUSTRIAL INSTRUMENTS DIVISION
1300 Rock Street, Rockford, Illinois, U.S.A., 61101

F-16199-1 BK JUNE 1977

LITHO IN U.S.A.

520 Series
6. ALARM BOARDS
Circuit Description And Service

6.1 GENERAL

Connections and adjustments for the Alarm Circuit are given in the Installation and Wiring Section for this manual. The alarm circuit is a simple voltage sensing circuit that drives a relay with an alarm contact rating of 2A at 120 Vac. The ALARM SET resistor R1 on the Main Board generates the reference voltage to which the process or deviation signal is compared at the input pins of IC1 on the alarm board. The ALARM SET resistor R1 is located at the upper left corner of the main board schematic, Figure 3-3.

6.2 PROCESS AND DEVIATION ALARMS

The operation of both alarms is the same except for the input. The Process Signal input is on pin 5 on Figure 6-1. The Deviation Signal input is on pin 4 on Figure 6-2. If either the Deviation or Process Signal causes IC1 to turn on, the positive going output of IC1 turns on Q1, energizing K1. When K1 is energized, the front panel red alarm lamp goes off and remains off until IC1 turns off, deenergizing K1.

6.3 DEVIATION BAND ALARM

The Deviation Signal input is on pin 4 on Figure 6-3. IC1B and D1 form an "absolute value" circuit. The polarity of the "error" signal on the cathode of D1 always goes from 0 Vdc to a positive voltage with either a positive or a negative Deviation Signal on pin 4. The incoming Deviation Signal can swing to +4 Vdc or to −4 Vdc, depending on whether the process is above or below setpoint. The amplitude of the voltage on the cathode of D1 must always equal the amplitude of the voltage of the Deviation Signal. For example, if the Deviation Signal is either −4 Vdc or +4 Vdc, the voltage from the cathode of D1 to pin 8 (common) is +4 Vdc in both cases. The "error" voltage on the cathode of D1 is compared with the alarm trip point voltage set by the ALARM SET resistor R1 on the Main Board. If the "error" signal causes IC1 to turn on, the positive going output of IC1 turns on Q1, energizing K1. When K1 is energized, the front panel red lamp goes off and remains off until IC1 turns off.

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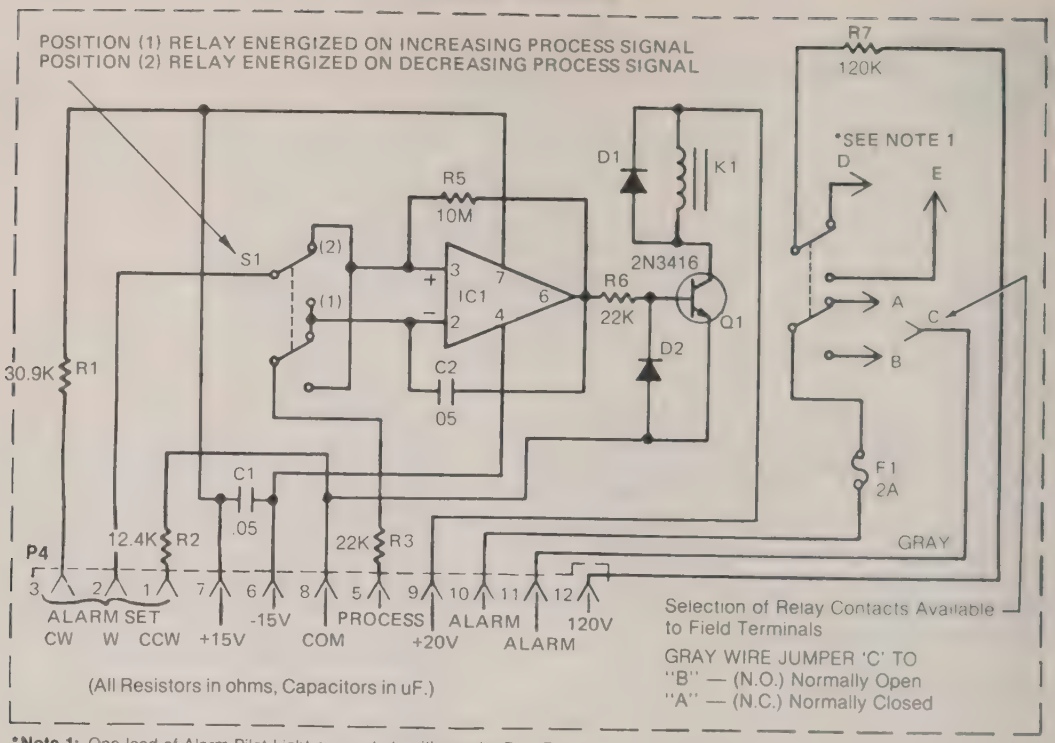
PROCESS ALARM



***Note 1:** One lead of Alarm Pilot Light connects to either point D or E. The other lead connects to pin 1 on the Main Board

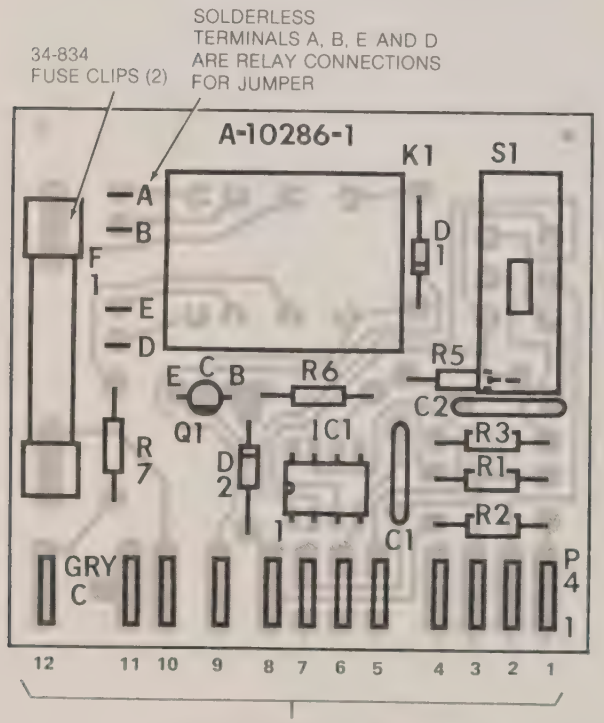
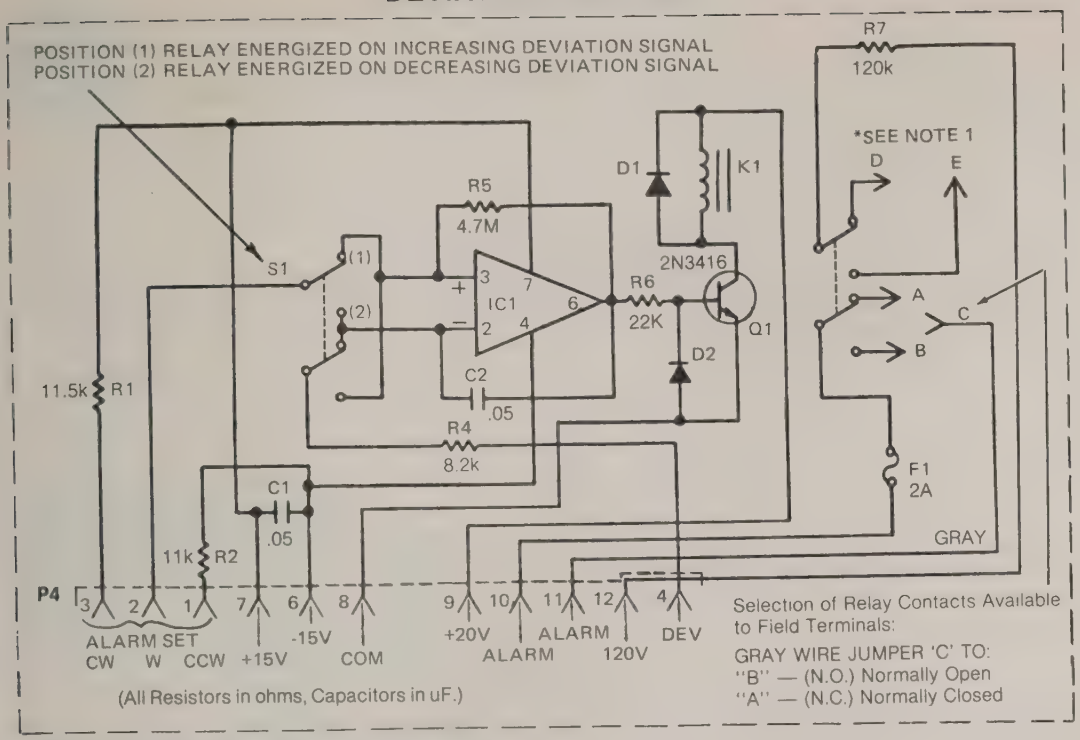


Figure 6-1. Process Alarm Board A-10286-1 and Schematic

Table 6-1. Process Alarm Board A-10286-1 Parts List

Symbol	Part Number	Description
		CAPACITORS
C1,2	39-325	.05uF, ±20%, 100 WVDC
		DIODES
D1,2	EYZP-384	250 PIV, If = 100 mA
		FUSE
F1	SYZE-206	2A, type AGC2
		INTEGRATED CIRCUIT
IC1	31-1012	741C Operational Amplifier
		RELAY
K1	38-205	DPDT, 20 vdc, 12 mA
		TRANSISTOR
Q1	31-082	2N3416, NPN
		RESISTORS
		Resistors are ±10% tolerance, 1/4W, unless stated otherwise
R1	CYZR-861-348	30.9k ohms, ±1%, 1/8W
R2	CYZR-861-310	12.4k ohms, ±1%, 1/8W
R3	CYZR-836-334	22k ohms
R5	40-1871	10M ohms
R6	40-1950	22k ohms
R7	40-1705	120k ohms, ±1%
		SLIDE SWITCH
S1	32-388	DPDT

DEVIATION ALARM



***Note 1:** One lead of Alarm Pilot Light connects to either point D or E. The other lead connects to pin 1 on the Main Board

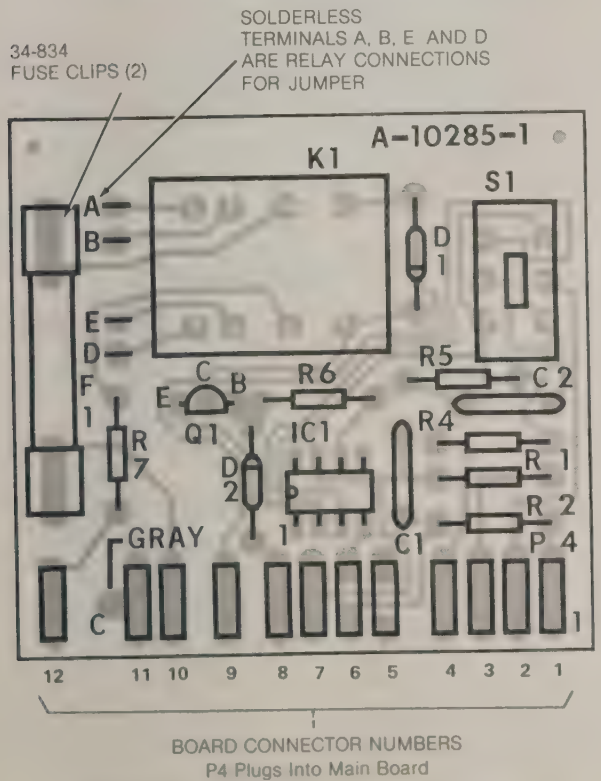
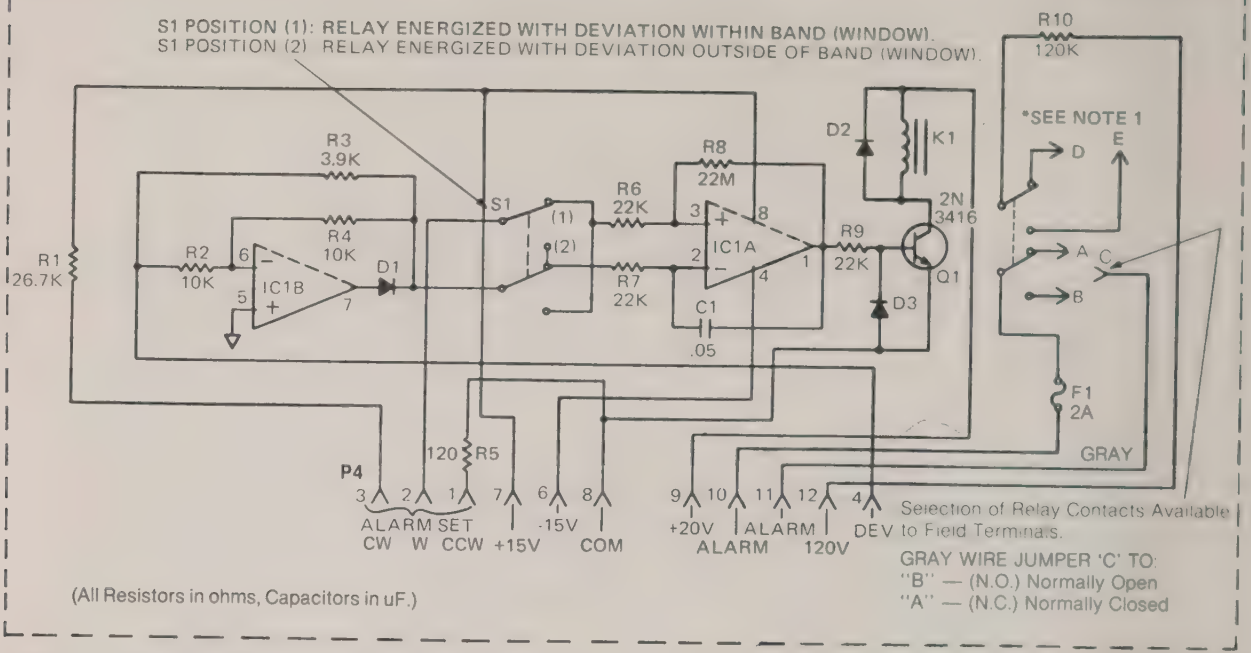


Figure 6-2. Deviation Alarm Board A-10285-1 and Schematic

Table 6-2. Deviation Alarm Board A-10285-1 Parts List

Symbol	Part Number	Description
		CAPACITORS
C1,2	39-325	.05uF, ±20%, 100 WVDC
		DIODES
D1,2	EYZP-384	250 PIV, If = 100 mA
		FUSE
F1	SYZE-206	2A, type AGC2
		INTEGRATED CIRCUIT
IC1	31-1012	741C Operational Amplifier
		RELAY
K1	38-205	DPDT, 20 Vdc, 12 mA
		TRANSISTOR
Q1	31-082	2N3416, NPN
		RESISTORS
	Resistors are ±10% tolerance, 1/4W, unless stated otherwise	
R1	CYZR-861-307	11.5k ohms, ±1%, 1/8W
R2	CYZR-861-305	11.0k ohms, ±1%, 1/8W
R4	40-1552	8.2k ohms
R5	40-1907	4.7M ohms
R6	40-1950	22k ohms
R7	40-1706	120k ohms ±5%
		SLIDE SWITCH
S1	32-388	DPDT

DEVIATION BAND ALARM



***Note 1:** One lead of Alarm Pilot Light connects to either point D or E. The other lead connects to pin 1 on the Main Board

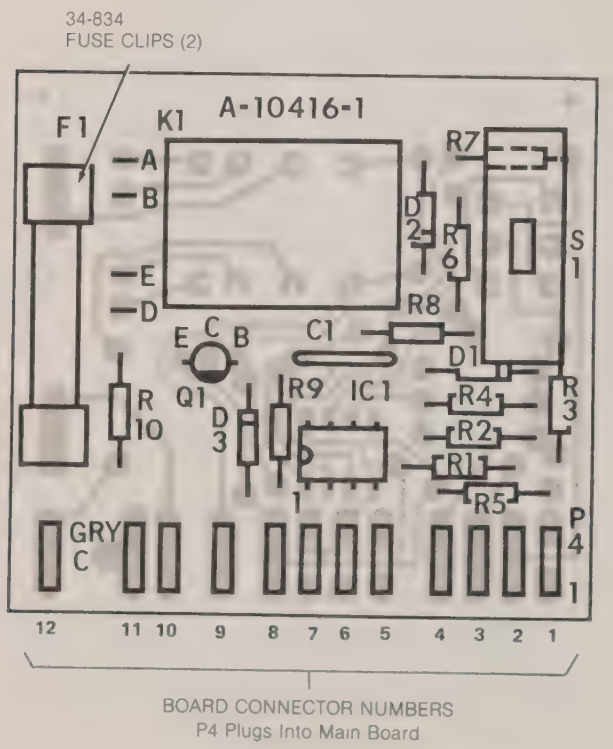


Figure 6-3. Deviation Band Alarm Board A-10416-1 and Schematic

Table 6-3. Deviation Band Alarm Board A-10416-1 Parts List

Symbol	Part Number	Description
		CAPACITOR
C1	39-325	.05uF, ±20%, 100 WVDC
		DIODES
D1,2,3	EYZP-384	250 PIV, If = 100 mA
		FUSE
F1	SYZE-206	2A, type AGC2
		INTEGRATED CIRCUIT
IC1	31-1015	Dual Minidip Operational Amplifier
		RELAY
K1	38-205	DPDT, 20 Vdc, 12 mA
		TRANSISTOR
Q1	31-082	2N3416, NPN
		RESISTORS
		Resistors are ± 10% tolerance 1/4W unless stated otherwise
R1	CYZR-861-342	26.7k ohms, ±1%, 1/8W
R2,4	CYZR-861-301	10k ohms, ±1%, 1/8W
R3	40-1557	3.9k ohms
R5	40-1758	120 ohms
R6,7,9	40-1950	22k ohms
R8	40-1857	22M ohms
R10	40-1706	120k ohms, ± 5%
		SLIDE SWITCH
S1	32-388	DPDT

Barber-Colman Company
INDUSTRIAL INSTRUMENTS DIVISION
1700 Rock Street, Rockford, Illinois, U.S.A., 61101

520 Series
7. CONTROL MODE BOARDS
Circuit Description And Service

7.1 Proportional plus Integral plus Derivative Board A-10514

7.1.1 CIRCUIT DESCRIPTION

See Figure 7-1. The Derivative (RATE) Circuit generates a correction signal that is a time derivative of the input signal to the Operational Amplifier (error signal). Since the correction signal is a derivative with respect to time, the Derivative circuit is operative only when the input signal is changing.

The bias of FET Q1A, Q1B and Q2A, Q2B is adjusted by resistor R3. The integral (RESET) action is generated by R11 and C4. The range of RESET adjustment is from 0.06 to 6 repeats per minute by R11. Field Effect Transistors Q1A, Q1B and Q2A, Q2B are connected in an emitter follower-current source configuration. Emitter follower Q2A has the high input impedance required for long integrating time constants. Emitter follower Q1A has the high impedance required for the long derivative times. Derivative (RATE) time is adjusted from 0 to 3 minutes by R6. The derivative action is generated by R6, C2 and C3.

RESET INHIBITION occurs when the DEMAND signal (output on pin 6 of IC5 on the Main Board) on pin 1 of P3 goes to the positive limits of the proportional band. The voltage at which inhibition occurs varies with the output control form board; and, on the dual output control forms H, J and K, also with the GAIN RATIO setting. Part of the circuit which establishes the inhibition voltage is located on the output control form board.

For output control forms H, J and K; with a GAIN RATIO setting of 4:1, inhibition occurs at 2.4 Vdc (for 1:1 it occurs at 6 Vdc). The inhibition voltage varies proportionally with GAIN RATIO settings so that inhibition occurs near the positive limit of the proportional band.

When the limit voltage is exceeded, a transistor on the output board turns on, which turns on control mode board transistor Q3 and reduces the voltage across R11 and C4 to 0.6 Vdc.

For all other output control forms, a resistor on the output control form board establishes the correct inhibition voltage (+6 Vdc).

The effect of the inhibition circuit action is to clamp the Integral(RESET)action to zero when the DEMAND signal exceeds the proportional band. This prevents excessive charge from accumulating on C4 during the time the controller is outside its proportional band. As the process signal again enters the proportional band, the output drops below 100% and normal circuit action is restored.

7.1.2 CALIBRATION OF FIELD EFFECT BIAS

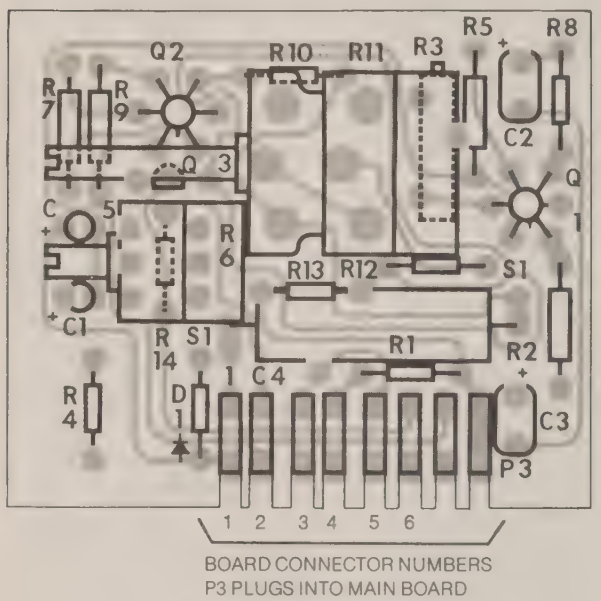
Adjustments on the Main Board need not precede this adjustment.

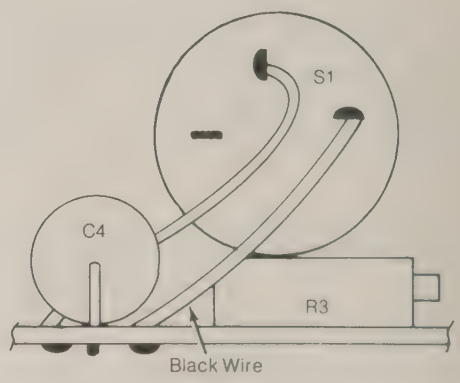
1. Unplug the Output Control Form Board from P5.
2. Short pins 1, 2, and 7 of P5 on the Main Board.
3. Turn off the front panel RESET control fully CCW to the OFF position.
4. Connect a precision digital voltmeter from the wiper of R3 to pin 7 of P5.
5. Adjust R3 until 0 Vdc ± .0001 Vdc is obtained.
6. Remove the shorting jumpers from pins 1, 2 and 7 of P5 and plug in the Output Control Form Board.
7. Allow power to remain on to the instrument and then perform any required adjustments for the Output Board Circuit, Section 8 of this manual.

Table 7-1. Parts List, Proportional Plus Integral Plus Derivative Board A-10514

Symbol	Part Number	Description
		CAPACITORS
C1,5	39-442	4.7 uF, ±20%, 20 WVDC
C2,3	39-437	68 uF, ±20%, 15 WVDC
C4	E13-89	10 uF, ±20%, 50 WVDC
		DIODE
D1	EYZP-384	250 PIV, I_f = 100mA
		TRANSISTORS
Q1A, 1B, and Q2A, 2B	31-157	2N3956, Factory selected dual FET
Q3	EYZP-623	2N4126

		RESISTORS
Resistors are ±10% tolerance, 1/4W, unless stated otherwise		
R1	CYZR-481-300	220 ohms
R2	CYZR-862-201	1k ohms, ±1%
R3	29-390	Variable, 1k ohms, ±10%, 3/4 W
R4,13	40-1847	47k ohms
R5,7,9	CYZR-862-218	1.5k ohms, ±1%
R6	29-334-1	RATE pot, dual, 5M, 0.5M, ±20% 1/5W
R8,10,14	40-1314	100k ohms
R11	29-372-1	RESET pot, dual 50M, ±30%, 1/2 W
R12	40-1763	1M, ±10%
		ROTARY SWITCH
S1		SPDT, Part of R11





View of S1 Wiring

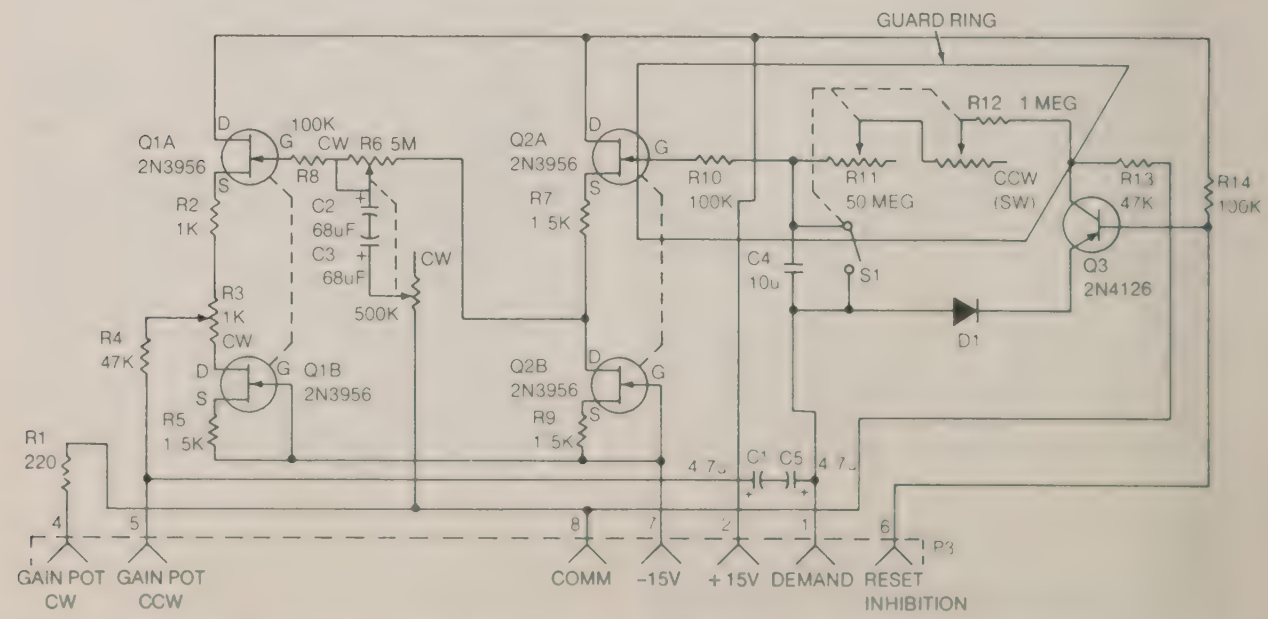


Figure 7-1. Proportional Plus Integral Plus Derivative Board A-10514 and Schematic

7.2 Proportional plus Integral Board A-10281

See Figure 7-2. The bias of FET Q1A and Q1B is adjusted by resistor R2. The integral (RESET) action is generated by R6 and C2. The range of RESET adjustment is from 0.06 to 6 repeats per minute. Field Effect Transistors Q1A and Q1B are connected in an emitter follower-current source configuration. The emitter follower has the high input impedance required for long integrating time constants. RESET INHIBITION occurs when the DEMAND signal (output on pin 6 of IC5 on the Main board) on pin 1 of P3 goes to the positive limits of the proportional band. The voltage at which inhibition occurs varies with the output control form board; and, on the dual output control forms H, J and K, also with the GAIN RATIO setting. Part of the circuit which establishes the inhibition voltage is located on the output control form board. For single output controllers, inhibition occurs at +6 Vdc on pin 1 of P3.

For output control forms H, J and K; with a GAIN RATIO setting of 4:1, inhibition occurs at 2.4 Vdc (for 1:1 it occurs at 6 Vdc). The inhibition voltage varies proportionally with GAIN RATIO settings so that inhibition occurs near the positive limit of the proportional band.

When the limit voltage is exceeded, control mode board transistor Q2 turns on, reducing the voltage across R6 and C2 to 0.6 Vdc.

The effect of the inhibition circuit action is to clamp the Integral (RESET) action to zero when the DEMAND signal exceeds the proportional band. This prevents excessive charge from accumulating on C2 during warm-up or on increase in setpoint. As the process signal again enters the proportional band, the output drops below 100% and normal circuit action is restored.

7.2.2 CALIBRATION OF FIELD EFFECT BIAS

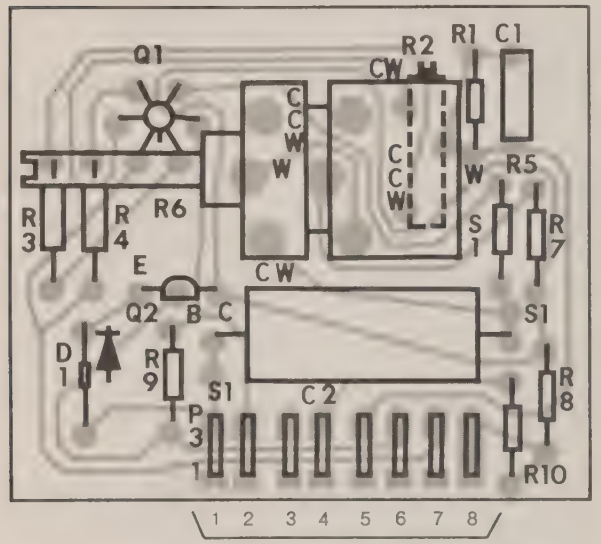
Adjustments on the Main Board need not precede this adjustment.

1. Unplug the Output Control Form Board from P5.
2. Short pins 1, 2, and 7 of P5 on the Main Board.
3. Turn off the front panel RESET control fully CCW to the OFF position.
4. Connect a precision digital voltmeter from the wiper of R3 to pin 7 of P5.
5. Adjust R3 until 0 Vdc ±.0001 Vdc is obtained.
6. Remove the shorting jumpers from pins 1, 2 and 7 of P5 and plug in the Output Control Form Board.
7. Allow power to remain on to the instrument and then perform any required adjustments for the Output Board Circuit, Section 8 of this manual.

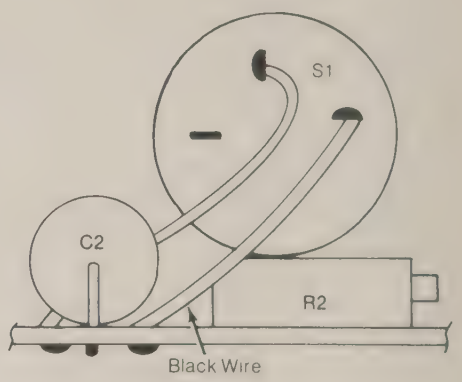
Table 7-2. Parts List, Proportional plus Integral
Board A-10281-1

Resistors are ±10% tolerance, 1/4 W unless stated otherwise.

Symbol	Part Number	Description
		CAPACITORS
C1	CYZR-803	.1 uF, ±20%, 250 WVDC
C2	E13-89	10uF, ±20%, 50 WVDC
		DIODE
D1	EYZP-384	250 PIV, I_f = 100mA
		TRANSISTORS
Q1A,B	31-157	2N3956, Factory Selected dual FET
Q2	EYZP-623	2N4126
		RESISTORS
R1,8	40-1847	47k ohms
R2	29-376	Variable, 500 ohms, 3/4W
R3	CYZR-862-209	1.21k ohms, ±1%
R4	CYZR-862-218	1.5k ohms, ±1%
R5,9	40-1314	100k ohms
R6	29-372-1	RESET pot, dual 50M, ±30%, 1/2W
R7	40-1763	1M, ±10%
R10	CYZR-481-300	220 ohms
		ROTARY SWITCH
S1		SPDT, Part of R6



BOARD CONNECTOR NUMBERS P3 PLUGS INTO MAIN BOARD



View of S1 Wiring

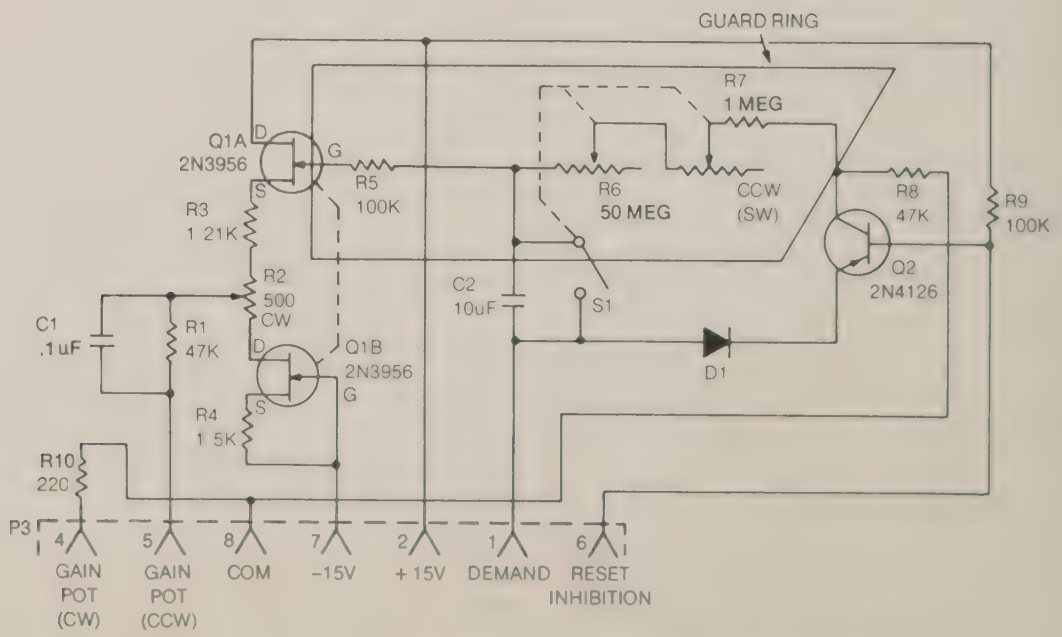


Figure 7-2. Proportional Plus Integral Board A-10281-1 and Schematic

7.3 Proportional Plus Manual Reset Board A-10280 Circuit Description

See Figure 7-3. The front panel MANUAL RESET resistor drives the output control form board from full off to full on when the controller is at zero deviation. Resistors R1 and R4 on this board and R23 on the Main Board determine the gain of the controller.

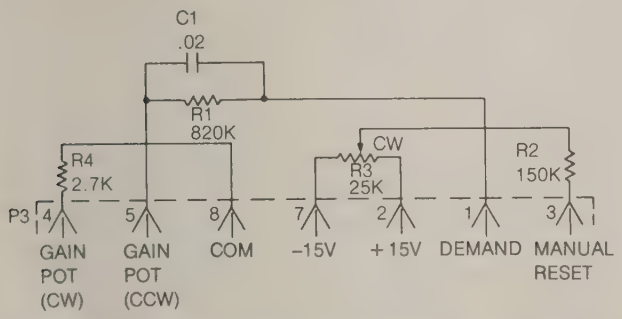
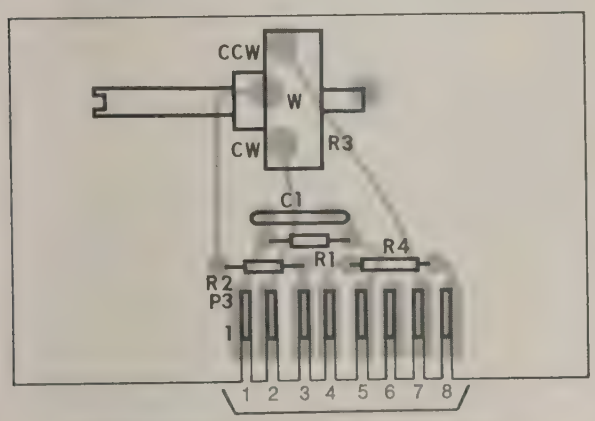


Figure 7-3. Proportional plus Manual Reset Board A-10280 and Schematic



Board Connector Numbers P3 Plugs Into Main Board

Table 7-3. Parts List, Proportional Plus Manual Reset Board A-10280

Symbol	Part Number	Description
		CAPACITORS
C1	39-416	.02uF, GMV, 600 WVDC
		RESISTORS
Resistors are ±10% tolerance, 1/4 W, unless stated otherwise.		
R1	CYZR-836-489	820k ohms
R2	40-1813	150k ohms
R3	29-371	RESET pot, 25k ohms, ±30%, 1/2 W
R4	CYZR-836-243	2.7k ohms

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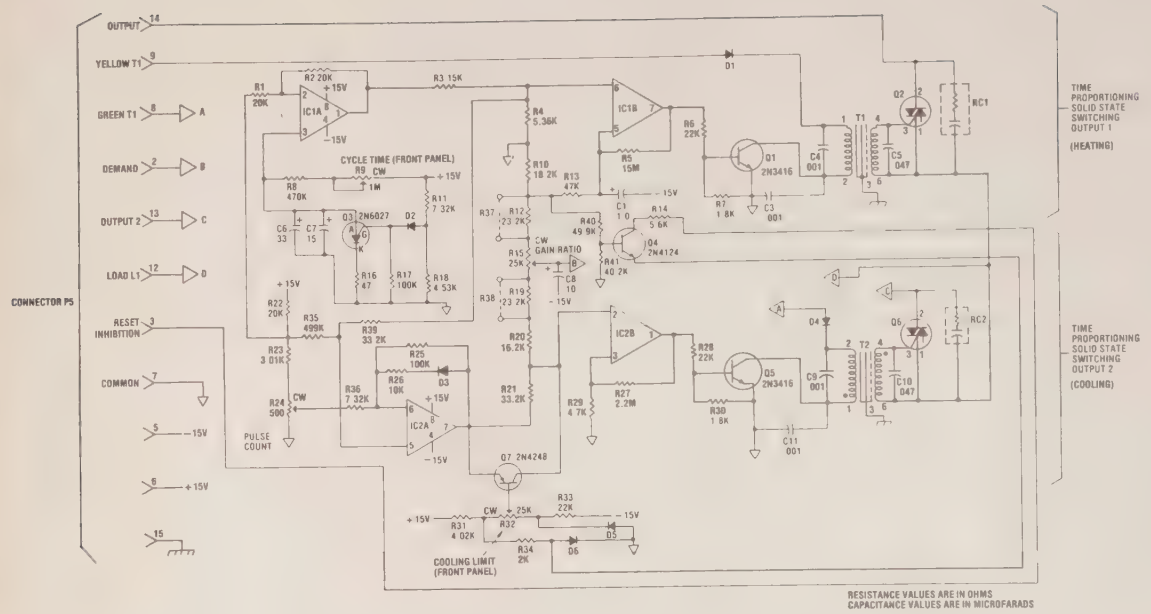
Table 8-1. Parts List, Dual Time-Proportioning Switching Output Board A-10337-3

Symbol	Part Number	Description
		CAPACITORS
C1	39-382	1uF, 20%, 35V, Tantalum
C3,4,9,11	39-063	.001uF, GMV, 600V, Ceramic
C5,10	39-449	.047uF, 10%, 250 WVDC, Mylar
C6	39-383	33uF, 20%, 25V, Tantalum
C7	39-391	15uF, 20%, 10V, Tantalum
C8	39-431	10uF, 20%, 35V, Tantalum
		DIODES
D1,2,3,4,6	EYZP-384	250 PIV, If = 100 mA, Silicon
D5	37-63	100 PIV, If = 320 mA, Germanium, IN270
		INTEGRATED CIRCUITS
IC1,2	31-1015	Dual Op Amp, Mini-Dip
		TRANSISTORS
Q1,5	31-082	Silicon NPN, 2N3416
Q2	31-155	Triac, 8A, 400 PIV
Q3	31-135	P.U.T., 2N6027 (G.E. D13T1)
Q4	EYZP-632	Silicon NPN, 2N4124
Q6	31-172	Triac, 8A, 400 PIV, Isolated Stud
Q7	31-126	Silicon, PNP, 2N4248
		RESISTORS
Resistors are 10% tolerance, 1/4W, unless stated otherwise.		
R1,2,22	CYZR-861-330	20k, 1%, 1/8W
R3	CYZR-861-318	15k, 1%, 1/8W
R4	CYZR-861-271	5360 ohms, 1%, 1/8W
R5	40-1810	15M
R6,28,33	40-1950	22k
R7,30	40-1842	1.8k
R8	CYZR-481-120	470k
R9	29-385	1M, 20%, 1/5W, CYCLE TIME potentiometer
R10	CYZR-861-326	18.2k, 1%, 1/8W
R11	CYZR-861-284	7.32k, 1%, 1/8W
R12,19	CYZR-861-336	23.2k, 1%, 1/8W
R13	40-1847	47k
R14	CYZR-836-273	5.6k
R15	E19-25	25k, 1/2W, GAIN RATIO potentiometer
R16	40-1751	47 ohms
R17,25	40-1314	100k
R18	CYZR-861-264	4530 ohms, 1%, 1/8W
R21,39	E19-24-351	33.2k, 1%, 1/8W
R23	CYZR-861-247	3.01k, 1%, 1/8W
R24	29-376	500 ohms, 3/4W, PULSE COUNT potentiometer
R26	CYZR-861-301	10k, 1%, 1/8W
R27	40-1846	2.2M
R29	CYZR-481-040	4.7k
R31	CYZR-861-259	4020 ohms, 1%, 1/8W
R32	29-370	25k, 20%, 1/4W, COOLING LIMIT potentiometer
R34	CYZR-861-230	2k, 1%, 1/8W
R35	CYZR-862-468	499k, 1%, 1/4W
R36	CYZR-788-014	8.25k, 1%, 1/8W
R37	CYZR-481-350	4.7 ohms. R37 is on Assembly A-10337-2 for the Standard Heat to Cool Gain Ratio of 1:1 to 4:1. R38 is deleted.
R38	CYZR-481-350	4.7 ohms. R38 is on Assembly A-11137 for the Optional Heat to Cool Gain Ratio of 1:1 to 1:4. R37 is deleted.
R40	CYZR-861-368	49.9k, 1%, 1/8W
R41	CYZR-861-359	40.2k, 1%, 1/8W
		SUPPRESSORS
RC1,2	50-1196	
		TRANSFORMERS
T1,2	30-323	Pulse



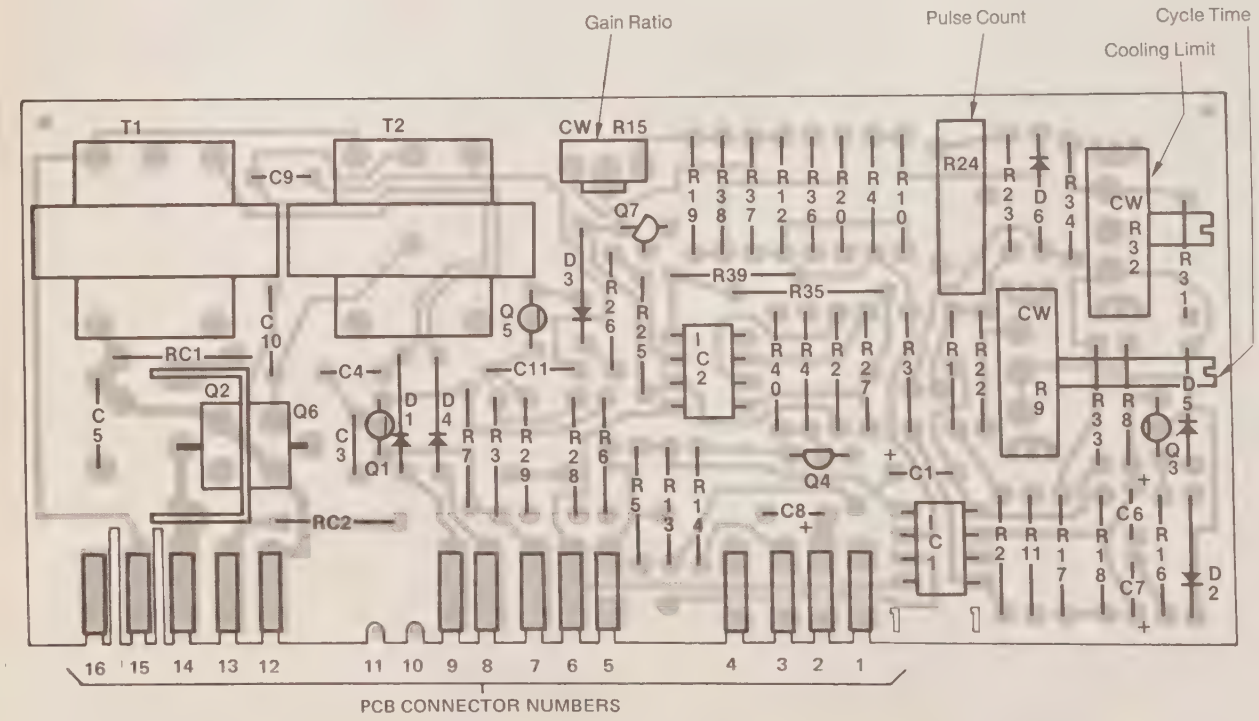


Figure 8-3. Dual Time-Proportioning Switching Output Board A-10337-3 and its Schematic

8. Output Board Circuit Description & Service

This is the last section of Service Manual 1252 IN 27. This manual section is only for blue boards.

8.1 GENERAL

Dual Time-Proportioning Switching Outputs Board A-10337-3 for Models 522H, 523H, and 524H: See Paragraph 8.2.

Current Output and Time-Proportioning Switching Output Boards. Listed in Table 8-2 for the Models 522J, 523J, 524J, 522K, 523K and 524K. See Paragraph 8.3.

8.2 DUAL TIME-PROPORTIONING SWITCHING OUTPUT BOARD A-10337-3 (MODELS 522H, 523H, and 524H)

8.2.1 Circuit Description

8.2.1.1 TIME-PROPORTIONING SWITCHING OUTPUT 1

See Figures 8-1, 8-2 and 8-3. The Demand Signal on Pin 2 of P5 is compared with a sawtooth waveform. This sawtooth is generated by Q3, C6, C7, R8 and R9, and appears between Terminal 3 of IC1A and common Pin 7 of P5. The sawtooth is buffered by IC1A and appears on Pin 6 of IC1B. When the Demand Signal is greater than the maximum amplitude of the sawtooth (the condition calling for full power to the load), the potential on Pin 7 of IC1B approaches +15 Vdc, and turns Q1 on, allowing the gate signal to turn Triac Q2 on. The rating of Q2 is 1A continuous, 10A inrush, 50 mA minimum.

8.2.1.2 TIME-PROPORTIONING SOLID STATE SWITCHING OUTPUT 2

The Demand Signal on Pin 2 of P5 is compared with a sawtooth waveform, This waveform is generated by Q3, C6, C7, R8 and R9, and appears between Terminal 5 of IC2A and common Pin 7 of P5. The shaped and amplified sawtooth waveform next appears on Pin 2 of IC2B. When the sum of the sawtooth waveform and the Demand Signal is negative, the output on Pin 1 of IC2B approaches +15 Vdc, and turns Q5 on, allowing the gate signal to turn on Triac Q6. The rating of Q6 is 1A continuous, 10A inrush, 50 mA minimum.

Fuse F1 on the Main Board is in series with the common of Triacs Q2 and Q6. The fuse is rated 2A at 250 Vac. Fuse size must not be exceeded. The copper foil on the Main Board will be destroyed at higher currents.

8.2.1.3 COOLING LIMIT AND GAIN RATIO CONTROL

COOLING LIMIT potentiometer R32 determines the limit voltage to the base of Q7. Q7 turns on when the sawtooth waveform on Pin 7 of IC2A exceeds the voltage on the base of Q7. When Q7 turns on, Comparator IC2B switches off the output.

R32 is on the board. R32 is adjusted through the front panel hole above the word SPREAD. R32 is continuously adjustable to limit the percent on time between 5 (CCW) and 100% (CW). This prevents excess cooling which can damage the barrel of an extruder.

GAIN RATIO potentiometer R15 is one leg of a voltage divider which reduces the Demand Signal voltage to Comparator IC1B, Pin 5; and to Comparator IC2B, Pin 2. The resistors in the two voltage dividers [R10, R12 for Output 1 (heating channel); R19, R20 for Output 2 (cooling channel)] are selected so that as the gain of Output 2 increases; the gain of Output 1 decreases proportionally. The total pulse band remains at a constant 12V when the GAIN RATIO potentiometer R15 is adjusted.

The GAIN RATIO potentiometer R15 should be adjusted by the user to compensate for the difference between the heating and the cooling gain of the controlled process.

The GAIN RATIO potentiometer R15 is inside the controller. To adjust R15, unplug the controller from its housing and insert a small screwdriver through the access hole in the metal plate on the right side of the controller. Service accessory Extender 24-2 is necessary if the adjustment is done while the process is operating. Once adjusted to match the gain differences of the process, R15 remains unaffected by either the front panel adjustable GAIN, RESET (integral action) or RATE (derivative action) Controls.

8.2.1.4 RESET WINDUP INHIBITION

When Output 1 (heating channel) reaches 100% on time, the increased Demand Signal Voltage at the base of Q4 turns Q4 on. When Q4 turns on, the Reset Inhibition Circuit on the Control Mode Board is activated. The voltage at which inhibition occurs varies proportionally with the gain ratio adjustment.

8.2.2 Calibration

8.2.2.1 FRONT PANEL CONTROLS

The CYCLE TIME Control R9 acts on both outputs. The COOLING LIMIT Control R32 is adjustable through the hole marked SPREAD. For the effect of varying the COOLING LIMIT Control, see Figure 8-1.

8.2.2.2 GAIN RATIO POTENTIOMETER R15

See Figure 8-1 for effect of varying R15.

8.2.2.3 OBTAINING FASTER CYCLE TIME

Cycle Time Potentiometer R9 is set to obtain a cycle time from 10 to 30 seconds nominal. This adjustment of cycle time can be changed to 3 to 10 seconds by removing Capacitor C6. The faster cycling rate will enable optimum control with a solid state contactor.

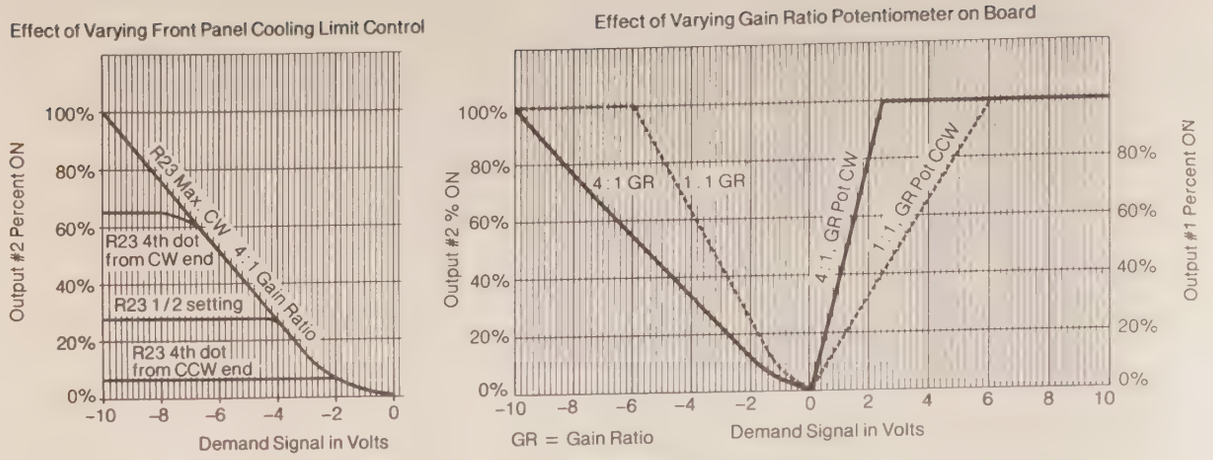


Figure 8-1. Output Characteristics, All Models

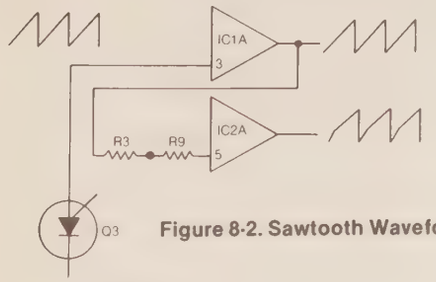


Figure 8-2. Sawtooth Waveform

8.2.2.4 ADJUSTMENT OF PULSE COUNT POTENTIOMETER R24

The adjustment of R24 establishes the relationship of the cooling output to the heating output shown in Figure 8-1. When making the transition from heating to cooling, control action must be maintained. In a proportional controller, loss of control action occurs if there is a dead zone between heating and cooling outputs. A slight overlap of the outputs, with small amounts of heating and cooling on together, is more desirable than loss of control action. This is very important when the controller is equipped with Integral (reset) action. An Integrator interprets a dead zone as though the entire control loop is open. It drifts until the Demand Signal produces an output which can result in severe process instability.

All adjustments on the Main Board and on the Control Mode Board (if any) must precede this adjustment. This adjustment should only be performed with an electronic counter. Short the Demand Signal of Pin 2 to common on Pin 7 of P6. Adjust R24 so Output 2 on time is 0.3%.

Fixed component values establish heating on time at 3% nominally. Thus, this adjustment assures 3.3% overlap under reference conditions and prevents a dead zone from occurring for all combinations of rated operating conditions.

8.2.3 Troubleshooting

1. Connect loads that require currents of 50 mA or more to the output terminals. The front panel Amber lamp for Output 1 and the White lamp for Output 2 will not turn off unless the load has this minimum current.
2. Short the Demand Signal on Pin 2 to common, Pin 7.
3. Amber light and White light should be on a very small percentage of the time.
4. Remove the short from Pin 2 to common.
5. Steps 1 thru 4 are suitable for field checking. For bench checking, proceed as follows.
6. Connect loads to the output terminals that require currents of 50 mA or more. The front panel Amber lamp for Output 1 and the White lamp for Output 2 will not turn off unless the load has this minimum current.
7. Connect a dc millivolt source to the controller rear panel input terminals 1 and 2. Be certain the polarity of the connections is correct. Adjust source for equivalent of midscale temperature.
8. Turn power on to the controller.
9. Turn the GAIN control fully CCW. Turn COOLING LIMIT control CW.
10. Now perform either a, b, or c, depending upon the model.
    a. Model 522 — Short Pins 1 and 7 of P5 on the Main Board. Connect a VOM between Pins 2 and 7 of P5 on the Main Board. Adjust the front panel RESET control until the VOM reads 0 Vdc. Remove the short from Pins 1 and 7 of P5. Disconnect the VOM. Proceed to Step 11.
    b. Model 523 — Turn the front panel RESET control fully CCW to the off position. Proceed to Step 11.
    c. Model 524 — Turn the front panel RESET control fully CCW to the off position. Turn the front panel RATE control fully CCW to the off position. Proceed to Step 11.
11. Turn the SETPOINT ADJUST control to minimum. The front panel Amber lamp should be dark. The White lamp should be on about 60% of the time.
12. Turn the SETPOINT ADJUST control to some setting near maximum. The White lamp should be dark. The Amber lamp should be on all the time. Do not depend on Fuse F1 on the Main Board to protect Triacs Q2 and Q6 — the primary purpose of the fuse is to protect the copper foil on the Main Board.

Table 8-2. Parts List, Current Output and Time-Proportioning Switching Output Boards

Models	522J, 523J, 524J	522K, 523K, 524K
Current Output	2–12 mAdc	4–20 mAdc
Vertical Output Board plugs into Horizontal Board	A-10753	A-10753-100
Resistor R10 on Vertical Board	2.74k, 1%, 1/4W (CYZR-862-243)	3160 ohms, 1% 1/4W (CYZR-862-249)
Horizontal Output Board plugs into Main Board. Standard Heat to Cool Gain Ratio of 1:1 to 4:1.	A-10340-2	A-10341-2
Horizontal Output Board plugs into Main Board. Heat to Cool Gain Ratio of 1:1 to 1:4 obtained by deleting R31 and connecting R32.	A-10340-102	A-10341-102
Resistor R8 on Horizontal Boards	464 ohms, 1%, 1/4W CYZR-862-165	280 ohms, 1%, 1/4W CYZR-862-144

Table 8-2. (Continued) Small Output Board Parts List

Symbol	Part Number	Description
		CAPACITORS
C1,2	39-382	1uF, 20%, 35 WVDC, Tantalum
		DIODES
D1,2	EYZP-384	250 PIV, If = 100 mA
		INTEGRATED CIRCUIT
IC1	31-1015	Dual 741 Op Amp
		RESISTORS
Resistors are 10% tolerance, 1/4W, unless stated otherwise.		
R1	CYZR-481-200	56k
R2	29-378	10k, 20%, 1/2W, CURRENT OUTPUT Potentiometer
R3	40-1805	12k
R4	40-1552	8.2k
R5	CYZR-861-316	14.3k, 1%, 1/8W
R6	CYZR-836-273	5.6k
R7	40-1847	47k
R8	CYZR-861-421	162k, 1%, 1/8W

Table 8-2. (Continued) Large Output Board Parts List

Symbol	Part Number	Description
		CAPACITORS
C1	39-383	33uF, 20%, 25 WVDC, Tantalum
C2	39-391	15uF, 20%, 10 WVDC, Tantalum
C3	39-200	60uF, 20%, 75 WVDC, Electrolytic
C4	39-400	10uF, 20%, 15 WVDC, Tantalum
C5	39-414	22uF, 10%, 15 WVDC, Tantalum
C6	39-431	10uF, 20%, 35 WVDC, Tantalum
C7,8	39-063	.001uF, GMV, 600 WVDC
C9	39-325	.05uF, 20%, 100 WVDC
		DIODES
D1,2,4,5, 6,7,8,9	EYZP-384	250 PIV, 100 mA
D3	37-179	6.2V Zener, 5%, 400 mW, IN753A
D10	37-63	100 PIV, If = 320 mA, G.E. IN270
		DIODE BRIDGE
FWB1	37-182	100 PIV, at 70 Vac, If = 1A
		INTEGRATED CIRCUIT
IC1	31-1015	Dual 741 Op Amp
		TRANSISTORS
Q1	31-135	2N6027 (PUT)
Q2	31-153	D40D8 (NPN)
Q3	31-126	2N4248 (PNP)
Q4	31-082	2N3416 (NPN)
Q5	31-155	Triac, 8A, 400 PIV
		RESISTORS
Resistors are 10% tolerance, 1/4W, unless otherwise stated.		
R1	CYZR-861-264	4530 ohms, 1%, 1/8W
R2	40-1314	100k
R3	40-1751	47 ohms
R4	40-1552	8.2k
R5,15,29	CYZR-861-284	7320 ohms, 1%, 1/8W
R6	29-385	1M, 20%, 1/5W, CYCLE TIME Potentiometer
R7	CYZR-481-120	470k
R9	CYZR-861-350	32.4k, 1%, 1/8W
R10	29-390	1k, 3/4W, PULSE COUNT Potentiometer
R11	CYZR-861-230	2k, 1%, 1/8W
R12	CYZR-481	1k
R13	40-1922	6.8k
R14	CYZR-861-368	49.9k, 1%, 1/8W
R16	40-1873	330k
R17	CYZR-788-046	17.4k, 1%, 1/8W
R18	E19-24-366	47.5k, 1%, 1/8W
R19	CYZR-861-342	26.7k, 1%, 1/8W
R20	CYZR-481-040	4.7k
R21	E19-25	25k, 1/2W, GAIN RATIO Potentiometer
R22	CYZR-861-339	24.9k, 1%, 1/8W
R23	E19-26	25k, 20%, COOLING LIMIT Potentiometer
R24,25	40-1950	22k
R26	40-1846	2.2M
R27	CYZR-861-336	23.2k, 1%, 1/8W
R28	40-1842	1.8k
R30	40-1845	39k
R31,32	CYZR-481-350	4.7 ohms
R33	E19-24-293	9.09k, 1%, 1/8W
		RC NETWORK
RC1	50-1196	
		TRANSFORMERS
T1	30-322	Modulator
T2	30-323	Pulse

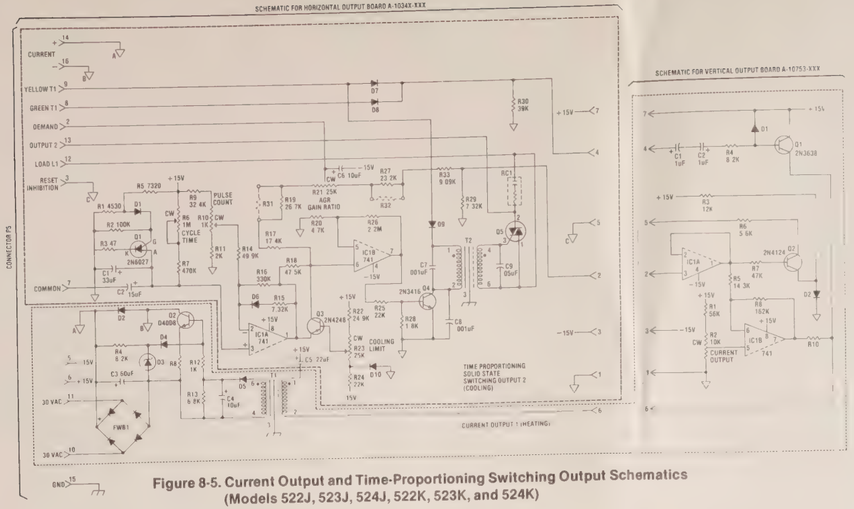


Figure 8-5. Current Output and Time-Proportioning Switching Output Schematics (Models 522J, 523J, 524J, 522K, 523K, and 524K)

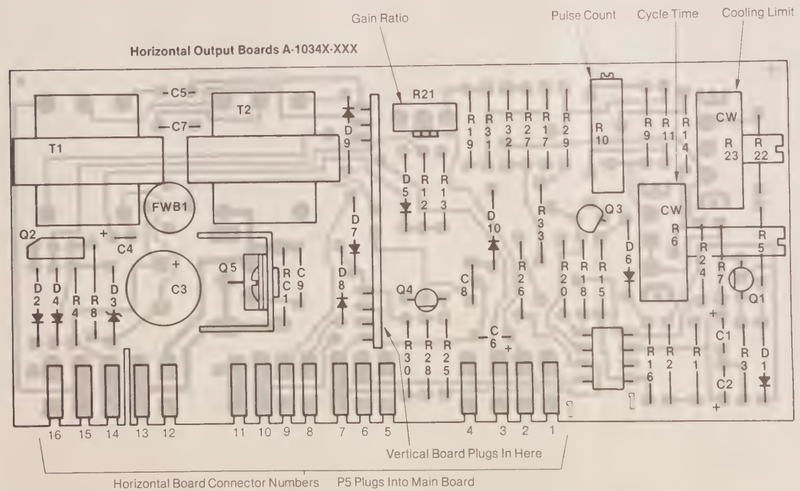
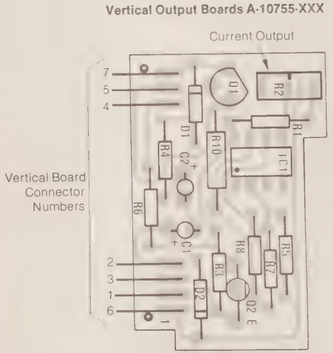


Figure 8-6. Current Output and Time-Proportioning Switching Output Boards (Models 522J, 523J, 524J, 522K, 523K, and 524K)



8.3.2.4 CALIBRATION OF NOMINAL CURRENT OUTPUT OF 2–12 mAdc ON BOARD A-10753-XXX

1. Short Pins 2 and 7 of P5.
2. A 0–15 mAdc meter is required. Also required is a 1500 ohm resistive load. Connect the meter and the resistor in series across rear panel Terminals 13 and 14. Adjust R2 on the Output Control Form Board until the milliammeter indicates 2 mAdc ± .5 mAdc.
3. Remove the short from Pins 2 and 7 of P5. Disconnect all test equipment.

8.3.2.5 CALIBRATION OF NOMINAL CURRENT OUTPUT OF 4–20 mAdc ON BOARD A-10753-XXX

1. Short Pins 2 and 7 of P5.
2. A 0–25 mAdc meter is required. Also required is a 750 ohm resistive load. Connect the meter and the resistor in series across rear panel Terminals 13 and 14.
3. Adjust R2 on the Output Control Form Board until the milliammeter indicates 4 mAdc ± .5 mAdc.
4. Remove the short from Pins 2 and 7 of P5. Disconnect all test equipment.

8.3.2.6 RANGE SUPPRESSION

Potentiometer R2 is factory set for 2–12 mAdc for Current Output Board A-10753 and for 4–20 mAdc for Current Output Board A-10753-100. The spans cannot be changed; but, the range of the span can be suppressed to meet other standard ranges by adjusting R2. Turn R2 CCW to move span to higher range; and, conversely, turn R2 CW to move span to a lower range.

The 10 mAdc span of the 2–12 mAdc range can be moved to 0–10 mAdc. The adjustment cannot move the span below 0 mAdc.

The 16 mAdc span of the 4–20 mAdc range can be moved to 0–16 mAdc. Again the adjustment cannot move the span below 0 mAdc.

8.3.2.7 FINAL CONTROLLERS WITH SPANS LESS THAN FACTORY SET SPAN

The Current Output will drive final controllers with spans less than the rated span with some increase in gain. For example, the 2–12 mAdc range can be changed to a range of 0–10 mAdc by adjusting R2. No further adjustment is required to drive a final controller with an input span of 0–5 mAdc and an input resistance of 0–3000 ohms. However, the effective gain is doubled.

CAUTION

Final controllers must be capable of accepting 10 mAdc, since the Current Output Controller in the example can still generate 10 mAdc.

8.3.2.8 ADJUSTMENT OF PULSE COUNT POTENTIOMETER R10

The adjustment of R10 establishes the relationship of the cooling output to the heating output shown in Figure 8-1. When making the transistion from heating to cooling, control action must be maintained. In a proportional controller, loss of control action occurs if there is a dead zone between heating and cooling outputs. A slight overlap of the outputs, with small amounts of heating and cooling on together, is more desirable than loss of control action. This is very important when the controller is equipped with Integral (reset) action. An Integrator interprets a dead zone as though the entire control loop is open. It drifts until the Demand Signal produces an output which can result in severe process instability.

All adjustments on the Main Board and on the Control Mode Board (if any) must precede this adjustment. This adjustment should be performed on an electronic counter. Short the Demand Signal on Pin 2 to ground on Pin 7. Adjust R10 so Output 2 on time is 0.3%.

Fixed component values establish heating on time at 3% nominally. Thus, this adjustment assures 3.3% overlap under reference conditions and prevents a dead zone from occurring for all combinations of rated operating conditions.

8.3.3 Troubleshooting

1. Check both outputs by performing the following procedure. Connect a load to the terminals for Output 2 that requires a current of 50 mA or more. The front panel White lamp for Output 2 will not turn off unless the load has this minimum current.

   Short the Demand signal on Pin 2 to common on Pin 7. White light should be on a very small percentage of the time. For a nominal current output of 2–12 mAdc, the output current should be 2 mAdc. For a nominal current output of 4–20 mAdc, the output current should be 4 mAdc.

2. The current output can also be checked by performing the procedure given in either Paragraph 8.3.2.4 or 8.3.2.5.

ORDER REPLACEMENT BOARDS BY THE ASSEMBLY NUMBERS PREFIXED BY AN **A.**

8.3 CURRENT OUTPUT AND TIME-PROPORTIONING SWITCHING OUTPUT BOARDS LISTED IN TABLE 8-2 FOR THE MODELS 522J, 523J, 524J, 522K, 523K, AND 524K.

8.3.1 Circuit Description

See Figures 8-1, 8-4, and 8-5.

8.3.1.1 CURRENT OUTPUT 1

The Demand Signal of Pin 2 of P5 goes through R21, R27, R33, and IC1A. The d-c output of IC1B on Pin 7 is chopped by Q1. This chopped d-c voltage is placed across T1, rectifed by D5, and filtered by C4. The d-c voltage then goes to the base of output transistor Q2. Resistor R8 determines the output span, Resistors R10 and R8 vary with the current spans of 2–12 mAdc and 4–20 mAdc. The current output is limited by D3 and D4. The 2–12 mAdc output is limited to 14 mAdc. The 4–20 mAdc output is limited to approximately 22 mAdc. The red-blue windings from T1 on the Main Board go directly to Terminals 10 and 11 of P5 to supply the full wave rectifier FWB1. C3 is the filter capacitor.

Either Terminal 14 (positive) of Terminal 16 (negative) may be grounded or remain floating (isolated). Output Terminals 14 and 16 are short circuit proof. No damage will result from shorting the terminals. The output is a constant current output. This means that a specific output current in the span (for example, 7 mAdc) will remain constant for a load of 0 to 1500 ohms attached to Terminals 14 and 16.

8.3.1.2 TIME-PROPORTIONING SOLID STATE SWITCHING OUTPUT 2

The Demand Signal on Pin 2 of P5 is compared with a sawtooth waveform. This waveform is generated by Q1, C1, C2, R6 and R7, and appears between Terminal 3 of IC1A and common Pin 7 of P5. This shaped and amplified triangular waveform next appears on Pin 6 of IC1B. When the sum of the sawtooth waveform and the Demand Signal is negative, the output of Pin 7 approaches the +15 Vdc supply and turns Q4 on, allowing the gate signal to turn on Triac Q5. The rating of Q5 is 1A continuous, 20A inrush, 30 mA minimum.

Fuse F1 on the Main Board is in series with Triac Q5. The fuse is rated 2A at 250 Vac. Fuse size must not be exceeded. The copper foil on the Main Board will be destroyed at higher currents.

8.3.1.3 COOLING LIMIT AND GAIN RATIO CONTROL

COOLING LIMIT potentiometer R23 determines the limit voltage to the base of Q3. Q3 turns on when the sawtooth waveform on Pin 1 of IC1A exceeds the voltage on the base of Q3. When Q3 turns on, comparator IC1B switches off the output.

R23 is on the board. R23 is adjusted through the front panel hole above the word SPREAD. R23 is continuously adjustable to limit the percent on time between 5 (CCW) and 100% (CW). This prevents excess cooling which can damage the barrel of an extruder.

Comparator IC1A, Pin 3, and to Comparator IC1B, Pin 6. The resistors in the two voltage dividers [R27, R33 for Output 1 (heating channel); R19, R17, for Output 2 (cooling channel)] are selected so that as the gain of Output 2 increases; the gain of Output 1 decreases proportionally. The total pulse band remains at a constant 12V when the GAIN RATIO potentiometer R21 is adjusted.

The GAIN RATIO potentiometer R21 should be adjusted by the user to compensate for the difference between the heating gain and the cooling gain of the controlled process.

The GAIN RATIO potentiometer R21 is inside the controller. To adjust R21, unplug the controller from its housing and insert a small screwdriver through the access hole in the metal plate on the right side of the controller. Service accessory Extender 24–2 is necessary if the adjustment is done while the process is operating. Once adjusted to match the gain differences of the process, R21 remains unaffected by either the front panel adjustable GAIN, RESET (integral action) or RATE (derivative action) Controls.

8.3.1.4 RESET WINDUP INHIBITION

When Output 1 (heating channel) reaches 100% on time, the increased Demand Signal Voltage at the base of Q2 (Q2 is on the Vertical Plug-in Board A-10753-XXX) turns Q2 on. When Q2 turns on, the Reset Windup Inhibition Circuit on the Control Mode Board is activated. The voltage at which inhibition occurs varies proportionally with the gain ratio adjustment.

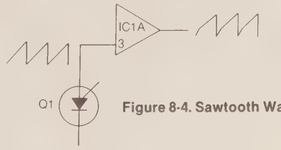


Figure 8-4. Sawtooth Waveform

8.3.2 Calibration

8.3.2.1 FRONT PANEL CONTROLS

The CYCLE TIME Control R6 acts only on Output 2. The COOLING LIMIT Control R23 is adjustable through the hole marked SPREAD. For the effect of varying the COOLING LIMIT Control see Figure 8-1.

8.3.2.2 GAIN RATIO POTENTIOMETER R21.

See Figure 8-1 for effect of varying R21.

8.3.2.3 OBTAINING FASTER CYCLING TIME FOR OUTPUT 2

Potentiometer R6 is set to obtain a cycle time from 10 to 30 seconds nominal. This adjustment of cycle time can be changed from 3 to 10 seconds by removing Capacitor C1. The faster cycling time will enable optimum control with a solid state contactor.

All adjustments on the Main Board and on the Control Mode Board (if any) must precede the following adjustment.

F-14859-3 BK

Barber-Colman Company
INDUSTRIAL INSTRUMENTS DIVISION
1300 Rock Street, Rockford, Illinois, U.S.A., 61101

LITHO IN U.S.A.

BARBEA COLMAN COMPANY
Industrial Instruments Division

McGoff Pyrotech, Inc.
Industrial Process Control Specialists

May 12, 1992

Mr. Nick Harris
Scientific Atlanta
Calibration Lab
3845 Pleasantdale Rd.
Atlanta, Ga. 30340

Dear Mr. Harris:

I don't have a manual on the 522B, but I am enclosing a manual for 522 H. The calibration procedure is the same. I have highlighted the procedure starting with 3.2.3 through 3.2.3.6. If you have any questions, give me a call.

Very truly yours

B. E. Ferguson
Service Engineer

BEF/dbm

ENCL.

McGoff Pyrotech, Inc.
2200 Norcross Parkway
Suite 230
Norcross, GA 30071
Phone (404) 840-9811
FAX (404) 729-1644

CAL LAB C-36

BARBER COLMAN COMPANY

Service Information

580 SERIES FIELD CALIBRATION

GENERAL

Service and calibration should only be performed by technically qualified personnel using appropriate test equipment and the procedure described herein.

The Model 580 is programmed with six standard ranges for Type J (I/C) Thermocouple. Advanced Microprocessor-based digital circuit design provides superior stability with minimal calibration shift. All 580 Series controllers are pre-tested, burned-in, and precisely calibrated at the factory for long, trouble-free life.

Changing Output Boards for Model Conversion (see 1254/ES 2) will not affect calibration of the 580 controller, but deterioration or replacement of Main Board components may necessitate a calibration check or adjustment.

An Extender Assembly may be used for service access or to quickly CHECK calibration when the instrument is installed in a housing and controlling a Process. Refer to bulletin 1254/IN 23 for wiring and operation description of Extender Assembly (B-C No. 24-49).

Calibration error measurement and adjustment should be made with the controller removed from the Process and set up on a lab bench. Ambient temperature in test area must be constant.

EQUIPMENT REQUIRED

Extender Assembly: 580 Series Extender assembly (B-C No. 24-49) is available (see 1254/PL 1) for service access or checking calibration.

Cut-Off Housing Rear Terminal Assembly: The rear terminal portion of a spare 580 Series Housing (A-11802) may be cut-off and used for bench calibration of a 580 controller.

Input Source: Either an UNCOMPENSATED (Millivolt Calibrated) Source such as B-C Portable Potentiometers PA10, PA11, PA24, or PA28; or a COMPENSATED (Cold-Junction Temperature Calibrated) Source such as PA12, PA13, PA14, PA15, PA24, or PA28, may be used to simulate the Process input signal to a 580 Series controller (see 1252/PL 20).

Digital Voltmeter: An accurate 4 1/2-Digit Digital Voltmeter having a low mV range down to 200 mVDC is REQUIRED to make critical calibration error measurements for adjustment of SPAN (R19 on Main Board) and ZERO (R37 on Main Board). Digital Voltmeter must display ±199.99 mVDC. The new FLUKE® Model 8050A 4 1/2-Digit Bench/Portable Digital Voltmeter is highly recommended (under $400.00). FLUKE® Model 8040A is also suitable.

IMPORTANT

Before checking or adjusting calibration, the Model 580 controller and required test equipment should be set up and powered for at least 10 minutes to stabilize components.

CHECKING CALIBRATION

Extender Assembly (B-C No. 24-49) and appropriate millivolt Input Source may be used to quickly CHECK calibration when:

1. Only a minimum Process disturbance can be tolerated, and;
2. The controller must remain panel mounted in an installed housing.

Note: To make calibration error MEASUREMENTS and ADJUSTMENTS, Input Source and controller should be removed from the Process and set up on a lab bench (see PRE-CALIBRATION SETUP, page 5).

Either an UNCOMPENSATED (Millivolt Calibrated) Source such as Barber-Colman Portable Potentiometers PA10, PA11, PA24, or PA28; or a COMPENSATED (Temperature Calibrated) Source such as a PA12. PA13, PA14, PA15, PA24, or PA28 (see 1252/PL 20) may be used to simulate the Process input signal to a 580 Series controller.

Before disturbing the Process to CHECK calibration, set up and wire the Extender Assembly and Input Source (see Table 1).

To initially maintain connection for Process control, place Extender Assembly switch S1 in the 'RTD' position and switch S2 in the 'PROC' position.

Then, quickly unplug controller, insert Extender Assembly, and plug controller into Extender.

Table 1. Extender Assembly Setup and Wiring to Check Calibration

Input Source	Input Wire Type (Note 1)	Input Terminals	S1 Switch Position (Note 2)	S2 Switch Position (Note 3)
Process			RTD	PROC
C/J Compensated (Temperature Calibrated)	Type J T/C Extension Wire	Extender Main Board 9(-) & 10(+)	T/C	TEST
Uncompensated (Millivolt Calibrated)	Copper	Extender Main Board 9(-) & 10(+)	CAL	TEST

Notes For Table 1:

1. Type J (I/C) thermocouple extension wire should be used between a C/J COMPENSATED Source and Extender Main Board terminals 9(-) and 10(+). The NEGATIVE (-) T/C wire is coded RED. Copper wire should be used when the Input Source is UNCOMPENSATED (millivolt Calibrated).
2. Switch S1 on Extender Main Board has three positions to determine which resistor is connected to establish the cold-junction reference at Extender Main Board screw terminals 8 and 9.

S1 Switch Position	Resistor at Term's 8 & 9	Input Wire to Extender Term's 9(-) & 10(=)
RTD*	NONE	NONE
T/C	BALCO	Type J T/C
CAL	1000Ω ±0.1%	Copper

*Switch S1 MUST be in the 'RTD' position when Switch S2 is in the 'PROC' position to avoid shunting the BALCO Resistor on Rear Terminals 8 and 9 of an installed housing. This position connects the 580 controller to the Process.

3. Switch S2 (on Extender Main Board) has two positions to connect controller terminals 8, 9, and 10 to either the installed housing rear terminals ('PROC' position); or to the screw terminals 8, 9, and 10 on the Extender Main Board ('TEST' position).

With the Extender Assembly and Input source connected per Table 1, calibration can now be CHECKED for a 580 Series controller under RATED OPERATING CONDITIONS (see 1254/DB 1).

Proceed as follows:

1. Confirm that the SELECT, SETPOINT/SETUP, RUN Toggle Switch located under the 580 controller access door is in the bottom 'RUN' position (Process temperature displayed).
2. Refer to Calibration Tables for the controller's range and apply the equivalent Input Source millivolts for each Calibration Check-Point Temperature from Table 2.
   (a.) Apply the equivalent millivolts for the 'LOW' end range check-point and allow controller to update and display a stable reading.
   The 580 digital display should indicate the 'LOW' end temperature ± the allowable tolerance from Table 2.
   (b.) Apply the equivalent millivolts for the 'HIGH' end range check-point and allow controller to update and display a stable reading.
   The 580 digital display should indicate the 'HIGH' end temperature ± the allowable tolerance from Table 2.
   (c.) Apply the equivalent millivolts for the 'MIDDLE' range check-point and allow controller to update and display a stable reading.
   The 580 digital display should indicate the 'MIDDLE' range temperature ± the allowable tolerance from Table 2.
3. If the 580 controller display readings are within the Calibration Tolerances described in Table 2, then Calibration Adjustment is NOT REQUIRED.
4. If the 580 controller display readings exceed the Calibration Tolerances described in Table 2, proceed to section describing PRE-CALIBRATION SETUP.

Table 2. Calibration Tolerances For Rated Operating Conditions

Range	Range Code	Calibration Check-Points and Display Readings		
		Low	High	Middle
32-600°F/J	0015	100°F ±4°F	550°F ±6°F	300°F ±5°F
32-800°F/J	0016	100°F ±4°F	750°F ±7°F	400°F ±6°F
32-999°F/J	0017	100°F ±4°F	950°F ±8°F	500°F ±6°F
0-400°C/J	0022	50°C ±2°C	350°C ±4°C	200°C ±3°C
0-600°C/J	0024	50°C ±2°C	550°C ±5°C	300°C ±4°C
32-400°F/J	0056	100°F ±4°F	350°F ±5°F	200°F ±5°F

Rated Accuracy: ±(0.5% of Reading +2°C) for °C Ranges
±(0.5% of Reading +3.6°F) for °F Ranges

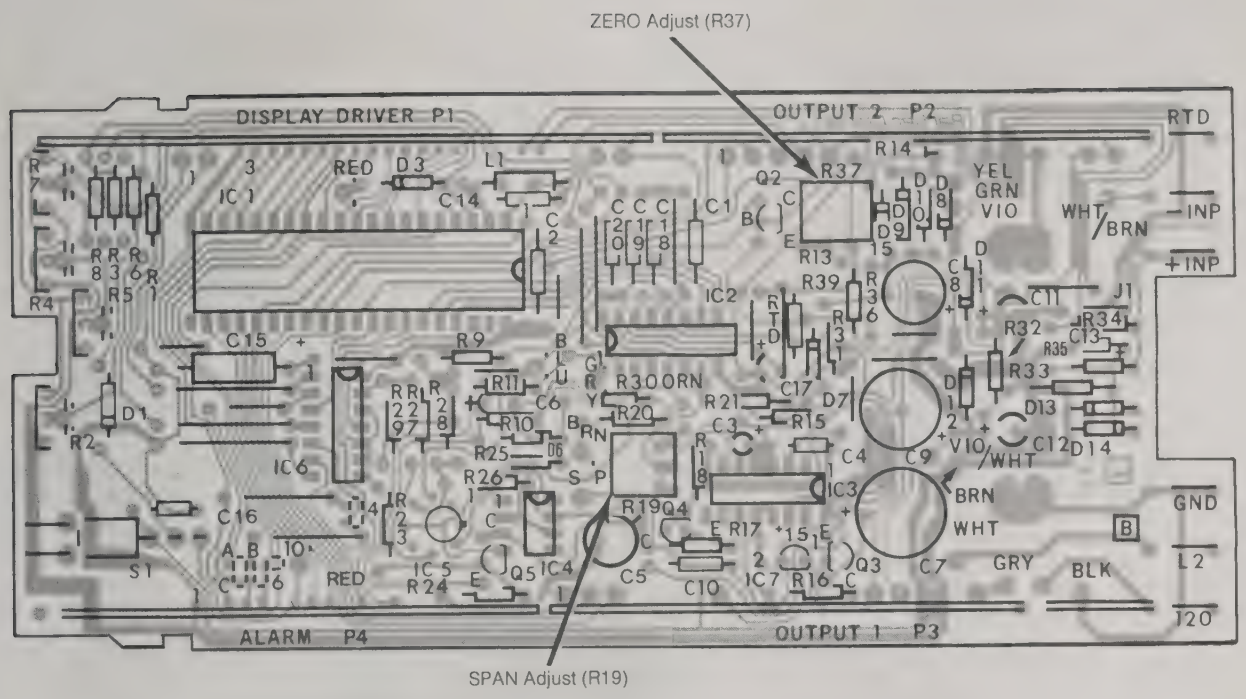


Figure 1. Calibration Adjustments on 580 Main Board

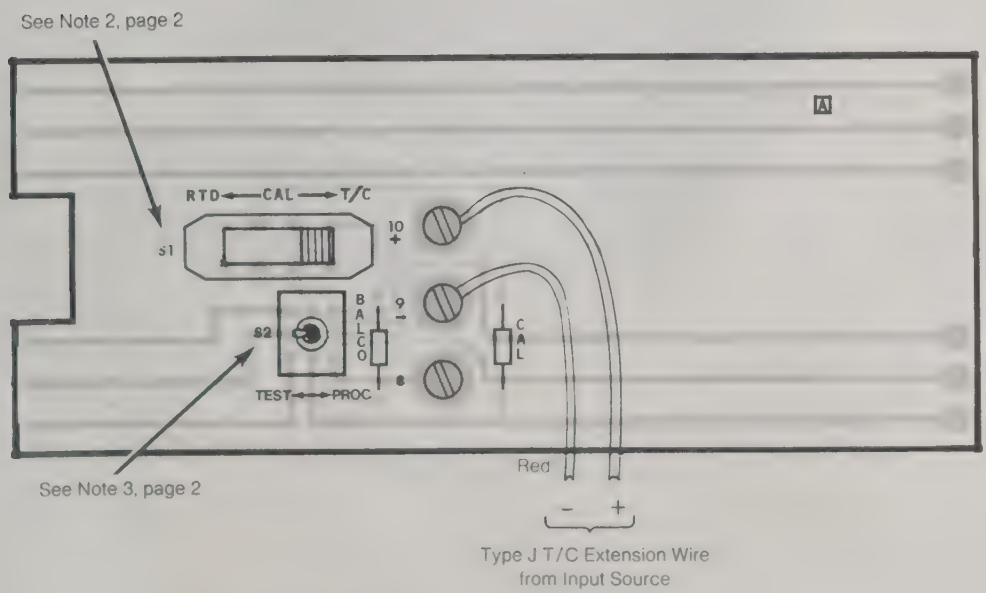


Figure 2. Extender Assembly Main Board

PRE-CALIBRATION SETUP

Before calibrating any 580 Series controller, remove Output Board(s). This will eliminate shock hazard from heatsinks and allow easy access for voltage measurement and calibration adjustment.

1. Rotate OPEN/LOCK SCREW (under access door) CCW and use wire PULL-HANDLE to withdraw controller from housing.
2. Disconnect PCB Support Bracket. (Release bracket latch at power transformer, lift bracket and remove.)
3. Unplug Output 2 Board (if present).
4. If Alarm Board is NOT present, simply unplug Output 1 Board.
5. If Alarm Board IS present, Output 1 Board and Alarm Board MUST be unplugged simultaneously; but first, Front assembly must be un-latched from Main Board.
6. Remove "snap-off" Front assembly by spreading both molding tabs that secure Main Board to Front (see Figure 3).
7. Unplug Output 1 Board and Alarm Board simultaneously and disconnect Output 1 Board from Alarm connector, P10.
8. If Alarm Board removal is NOT desired, Plug Alarm Board back into Main Board.
9. If Alarm Board removal IS desired, disconnect wires for Alarm LED's and remove Alarm Board (Refer to 580 controller Instruction Manual to re-connect LED wires).
10. Re-connect "snap-off" Front assembly to Main Board.
11. Insert 580 controller into a cut-off Housing Rear Terminal Assembly.

Note: Calibration error measurement and adjustment should be performed on a lab bench. Ambient temperature in test area must be constant.

12. Wire Input Source and connect appropriate cold-junction resistor to cut-off Housing Rear Terminal Assembly (see Figure 4 and 5 on page 6).

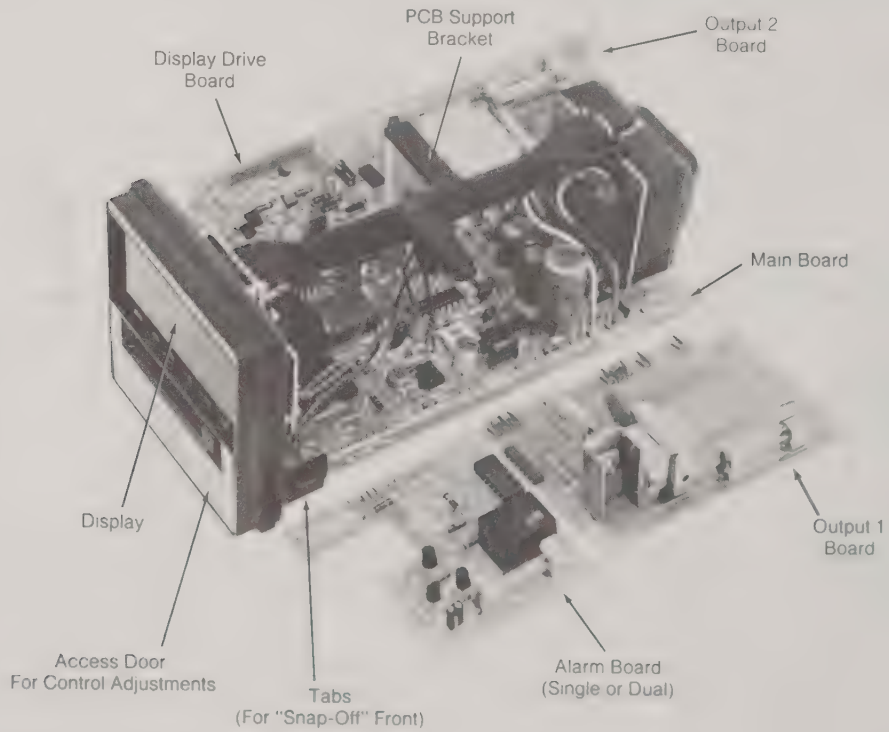


Figure 3. 580 Modular Construction

CALIBRATION WIRING

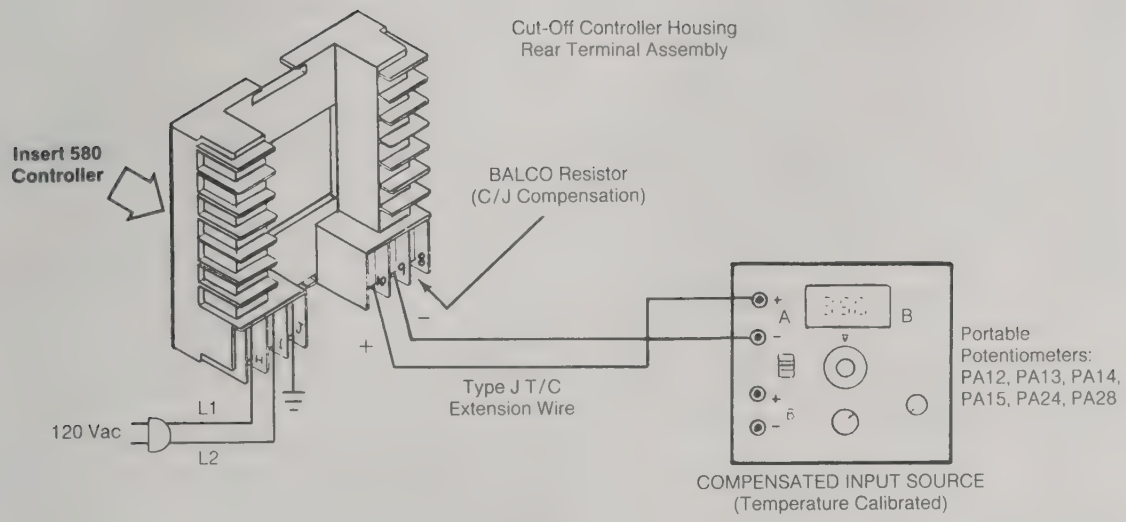


Figure 4. Wiring A Compensated Input Source (BALCO C/J Resistor On Rear Terminals 8 and 9)

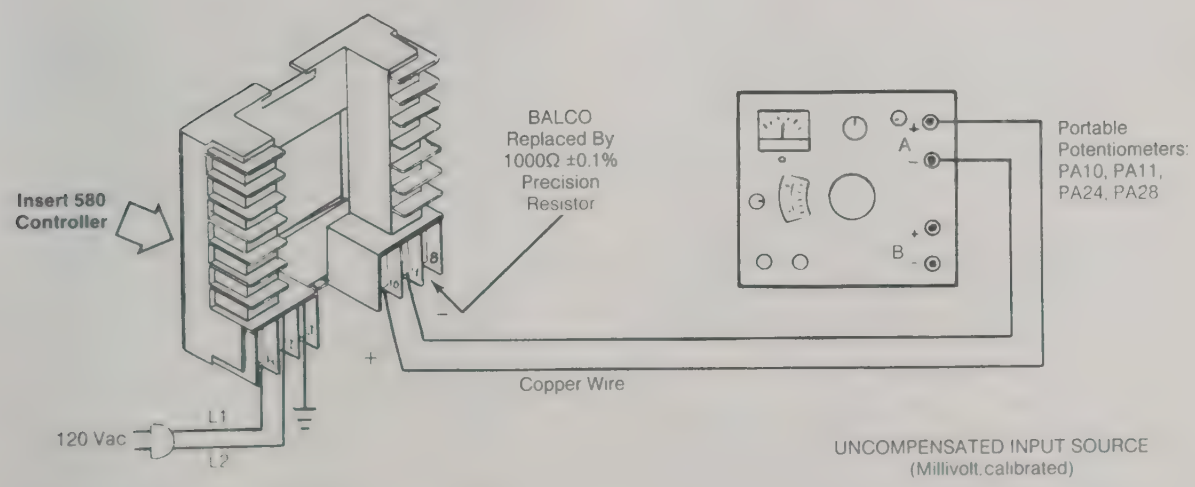


Figure 5. Wiring An Uncompensated Input Source (1000Ω ±0.1% Precision Resistor On Rear Terminals 8 And 9).

CALIBRATION ERROR MEASUREMENT AND ADJUSTMENT

GENERAL

If the Model 580 controller display readings exceed the Calibration Tolerances for each Calibration Check-Point (see Table 2, page 3), then re-calibration is necessary.

Warm-Up

After completing PRE-CALIBRATION SETUP (page 5), the Model 580 controller and required test equipment should be powered for at least 10 minutes to stablize components. Ambient temperature in test area must be constant.

Calibration Outline

The following steps outline the calibration procedure for a Model 580 controller:

1. Apply two input values to the controller (one near the high end and one near the low end of span).
2. Observe the temperatures displayed on the 580 digital readout.
3. Use the CALIBRATION ERROR CORRECTION TABLES (for the controller's Range) to determine millivolt correction values for SPAN and ZERO.
4. Measure SPAN and ZERO voltages and correct them by the amount indicated (either NO Correction, + Correction, or - Correction) in the CALIBRATION ERROR CORRECTION TABLES.

SPAN
ZERO

5. Seal Main Board potentiometers R19 (SPAN) and R37 (ZERO) to avoid calibration shift due to unit shock or vibration.

Calibration Procedure

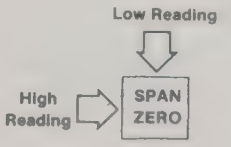
Proceed as follows:

1. Select the proper calibration tables ("Calibration Check-Points and Source mV" and "CALIBRATION ERROR CORRECTION TABLE") for the controller's Range.
2. Apply the high value input shown on the calibration table (either temperature or millivolts, depending on Input Source used for calibration).
3. Allow controller to update and display a stable reading (approximately 15 seconds) and then record the 'HIGH READING' value displayed on the 580 digital readout.
4. Apply the low value input shown on the calibrtion table (either temperature or millivolts, depending on Input Source used for calibration).
5. Allow controller to update and display a stable reading (approximately 15 seconds) and then record the 'LOW READING' value displayed on the 580 digital readout.
6. Using the appropriate CALIBRATION ERROR CORRECTION TABLE, locate the amount of Millivolt Correction for SPAN AND ZERO.

SPAN
ZERO

Note: If the display indications for 'HIGH READING' and 'LOW READING' are outside the limits of the CALIBRATION ERROR CORRECTION TABLES for Millivolt Correction, connect the 4 1/2-Digit Digital Voltmeter to the appropriate test-point and pre-adjust potentiometer R19 (SPAN) for 34 mVDC and R37 (ZERO) for 12 mVDC. (Refer to Step 8 and 10).

7. At the intersection of the 'HIGH READING' line and 'LOW READING' column, read the SPAN and ZERO millivolt correction values. The first millivolt value is the SPAN correction and the second millivolt value is the ZERO correction.



8. Connect a 4 1/2-Digit Digital Voltmeter to measure SPAN voltage. (DVM range should be ±199.99 mVDC).

   The recommended test-point for measuring the SPAN voltage is directly across the setpoint potentiometer mounted behind the 580 controller Front assembly.

Voltage Reading	DVM Lead	Test-Point
SPAN	Positive (+)	Brown Lead (Setpoint Pot. CW, #3)
	Negative (-)	Blue Lead (Setpoint Pot. CCW, #1)

   The SPAN voltage measured should be approximately 34 mVDC.

9. Read the SPAN voltage and carefully adjust potentiometer R19 (on 580 Main Board) to correct the value by the amount of SPAN millivolts determined in Step 7. Clockwise rotation of R19 decreases the SPAN voltage (plus mV corrction).
10. Connect the Digital Voltmeter to measure ZERO (cold-junction compensation) voltage. DVM range should be ±199.99 mVDC.

    The recommended test-point for measuring the ZERO (cold-junction compensation voltage is from Housing Rear Terminal 8 to circuit common (Setpoint Pot. Blue Lead, #1, CCW).

Voltage Reading	DVM Lead	Test-Point
ZERO	Positive (+)	Rear Terminal 8
	Negative (-)	Blue Lead (Setpoint Pot. CCW, #1)

The ZERO voltage measured should be approximately 12 mVDC.

CALIBRATION ERROR MEASUREMENT AND ADJUSTMENT (cont.)

11. Read the ZERO voltage and carefully adjust potentiometer R37 (on 580 Main Board) to correct the value by the amount of ZERO millivolts determined in Step 7. Clockwise rotation of R37 decreases the ZERO voltage (plus mV correction).

NOTE: Making the SPAN (R19) correction will affect the ZERO (R37) adjustment; Herefore, always read and adjust SPAN **before** reading and adjusting ZERO.

12. To check calibration accuracy, apply the high value and low value input signals shown on the calibration tables and confirm that the 580 digital display indicates the desired reading within the Calibration Tolerances described in Table 2 (pg. 3).
13. If the 580 controller display readings exceed the Calibration Tolerances described in Table 2, repeat the calibration procedure and re-adjust SPAN (R19 and ZERO (R37) potentiometers.
14. After the controller is calibrated, seal Main Board potentiometers R19 (SPAN) and R37 (ZERO) to avoid calibration shift due to unit shock or vibration.
15. Calibration is now complete. Disconnect power and unplug controller from cut-off Housing Rear Terminal assembly.
16. Refer to PRE-CALIBRATION SETUP (page 5) and replace Output Board(s) and Alarm Board (if present). Also, replace PCB Support Bracket.
17. Return the controller to the Process.

Notes for Calibration Check-Point Tables:
(Tables 3 Thru 8 on Pages 10 Thru 21)

1. Temperature Calibration Check-Points. Apply these °F or °C values directly when using an Input Source having Automatic cold-junction compensation and a temperature calibrated scale (Portable Potentiometers PA12, PA13, PA14, PA15, PA24, or PA28). BALCO C/J Resistor must be connected to rear terminals 8 and 9 on the cut-off Controller Housing Rear Terminal assembly. Type J T/C extension wire should be used between the COMPENSATED Input Source and cut-off Housing rear terminals 9(-) and 10(+).
2. Equivalent EMF millivolts for temperature Calibration Check-Points (see 1111/DB 10). Input Source millivolts must be corrected for reference temperature at the cold-junction. Apply these values from a millivolt calibrated Input Source such as PA10 or PA11 only after correcting for cold-junction at output terminals of Portable Potentiometer (PA10 or PA11). BALCO C/J Resistor must be connected to rear terminals 8 and 9 on the cut-off Controller Housing Rear Terminal assembly.

   When the output from a millivolt Calibrated Input Source (PA10 or PA11) is corrected (COMPENSATED) for cold-junction temperature, Type J T/C extension wire should be used between the Input Source and cut-off Housing rear terminals 9(-) and 10(+).
3. These millivolt values will appear at the output terminals of a COMPENSATED (Temperature Calibrated) Source (such as PA12, PA13, PA14, PA24, or PA28) if the Source cold-junction temperature is 77°F (25°C). Source output millivolts will vary for different cold-junction temperatures.

   To determine Source output millivolts for different cold-junction temperatures, measure the cold-junction temperature at Source output terminals and subtract the equivalent millivolts (for Type J T/C) from the NBS mV values for each calibration check-point (1.277 mV is subtracted for a cold-junction of 77°F (25°C)).

   BALCO C/J Resistor must be connected to rear terminals 8 and 9 on the cut-off Controller Housing Rear Terminal assembly. Type J T/C extension wire should be used between the COMPENSATED Input Source and cut-off Housing rear terminals 9(-) and 10(+).
4. Millivolt Input values from an UN-COMPENSATED (Millivolt Calibrated) Source such as PA10, PA11, PA24, or PA28.

   BALCO Resistor must be removed and a precision 1000Ω ±0.1% resistor (B-C No. CYZR-865-1) connected to rear terminals 8 and 9 on the cut-off Controller Housing Rear Terminal assembly. This will simulate a fixed 70°F (21.1°C) cold-junction reference temperature that is NOT affected by ambient temperature change.

   The values shown are the equivalent millivolts for each Calibration Check-Point at the simulated C/J reference temperature of 70°F (21.1°C) (1.076 mV has been subtracted from NBS mV values).

   Copper wire should be used between the UNCOMPENSATED (Millivolt Calibrated) Input Source and cut-off Housing rear terminals 9(-) and 10(+).

RANGE 32-600° F/J (CODE 0015)

Table 3. Calibration Check-Points and Source mV

(Temperature Calibrated) Check-Point (Note 1)	NBS Table mV (Note 2)	COMPENSATED (Temperature Calibrated) Source Output 77°F (25°C) C/J (Note 3)	UNCOMPENSATED (Millivolt Calibrated) Source Output 70°F (21.1°C) C/J (Note 4)
100°F	1.942 mV	0.665 mV	0.866 mV
300°F	7.947 mV	6.670 mV	6.871 mV
550°F	15.648 mV	14.371 mV	15.572 mV

Important: See Notes on page 9.

CALIBRATION ERROR CORRECTION TABLE

Table 3-1. Millivolt Correction

SPAN
ZERO

High Reading°F	Low Reading °F										
	95	96	97	98	99	100	101	102	103	104	105
540	-.38 +.14	-.45 +.11	-.53 +.08	-.60 +.05	-.68 +.02	-.75 -.01	-.83 -.05	-.90 -.08	-.98 -.11	-1.05 - .14	-1.13 - .17
541	-.30 +.14	-.38 +.11	-.45 +.08	-.53 +.05	-.60 +.02	-.68 -.01	-.75 -.04	-.83 -.07	-.90 -.10	-.98 -.14	-1.05 - .17
542	-.23 +.14	-.30 +.11	-.38 +.08	-.45 +.05	-.53 +.02	-.60 -.01	-.68 -.04	-.75 -.07	-.83 -.10	-.90 -.13	-.98 -.16
543	-.15 +.14	-.23 +.11	-.30 +.08	-.38 +.05	-.45 +.02	-.53 -.01	-.60 -.04	-.68 -.07	-.75 -.10	-.83 -.13	90 16
544	-.08 +.14	-.15 +.11	-.23 +.08	-.30 +.05	-.38 +.02	-.45 -.01	-.53 -.04	-.60 -.07	-.68 -.10	-.75 -.13	-.83 -.16
545	.00 +.15	-.08 +.11	-.15 +.08	-.23 +.05	-.30 +.02	-.38 -.01	-.45 -.04	-.53 -.07	-.60 -.10	-.68 -.13	-.75 -.16
546	+.08 +.15	.00 +.12	-.08 +.09	-.15 +.06	-.23 +.02	-.30 -.01	-.38 -.04	-.45 -.07	-.53 -.10	-.60 -.13	-.68 -.16
547	+.15 +.15	+.08 +.12	.00 +.09	-.08 +.06	-.15 +.03	-.23 .00	-.30 -.03	-.38 -.07	-.45 -.10	-.53 -.13	60 16
548	+.23 +.15	+.15 +.12	+.08 +.09	.00 +.06	-.08 +.03	-.15 .00	-.23 -.03	-.30 -.06	-.38 -.09	-.45 -.12	53 -16
549	+.30 +.15	+.23 +.12	+.15 +.09	+.08 +.06	.00 +.03	-.08 .00	-.15 -.03	-.23 -.06	-.30 -.09	-.38 -.12	45 15
550	+.38 +.15	+.30 +.12	+.23 +.09	+.15 +.06	+.08 +.03	.00 .00	-.08 -.03	-.15 -.06	-.23 -.09	-.30 -.12	38 15

(Table continued on next page)

RANGE 32-600 ° F/J (CODE 0015)

CALIBRATION ERROR CORRECTION TABLE

Table 3-1. Millivolt Correction (Cont.)

SPAN
ZERO

High Reading °F	Low Reading °F										
	95	96	97	98	99	100	101	102	103	104	105
550	+ .38 + .15	+ .30 + .12	+.23 +.09	+.15 +.06	+.08 +.03	.00 .00	-.08 -.03	-.15 -.06	-.23 -.09	-.30 -.12	-.38 -.15
551	+ .45 + .15	+ .38 + .12	+.30 +.09	+.23 +.06	+.15 +.03	+.08 .00	.00 -.03	-.08 -.06	-.15 -.09	-.23 -.12	-.30 -.15
552	+ .53 + .16	+ .45 + .12	+.38 +.09	+.30 +.06	+.23 +.03	+.15 .00	+.08 -.03	.00 -.06	-.08 -.09	-.15 -.12	-.23 -.15
553	+ .60 + .16	+ .53 + .13	+.45 +.10	+.38 +.07	+.30 +.03	+.23 .00	+.15 -.03	+.08 -.06	.00 -.09	-.08 -.12	-.15 -.15
554	+ .68 + .16	+ .60 + .13	+.53 +.10	+.45 +.07	+.38 +.04	+.30 +.01	+.23 -.02	+.15 -.06	+.08 -.09	.00 -.12	-.08 -.15
555	+ .75 + .16	+ .68 + .13	+.60 +.10	+.53 +.07	+.45 +.04	+.38 +.01	+.30 -.02	+.23 -.05	+.15 -.08	+.08 -.11	.00 -.15
556	+ .83 + .16	+ .75 + .13	+.68 +.10	+.60 +.07	+.53 +.04	+.45 +.01	+.38 -.02	+.30 -.05	+.23 -.08	+.15 -.11	+.08 -.15
557	+ .90 + .16	+ .83 + .13	+.75 +.10	+.68 +.07	+.60 +.04	+.53 +.01	+.45 -.02	+.38 -.05	+.30 -.08	+.23 -.11	+.15 -.14
558	+ .98 + .16	+ .90 + .13	+.83 +.10	+.75 +.07	+.68 +.04	+.60 +.01	+.53 -.02	+.45 -.05	+.38 -.08	+.30 -.11	+.23 -.14
559	+1.05 + .17	+ .98 + .14	+.90 +.10	+.83 +.07	+.75 +.04	+.68 +.01	+.60 -.02	+.53 -.05	+.45 -.08	+.38 -.11	+.30 -.14
560	+1.13 + .17	+1.05 + .14	+.98 +.11	+.90 +.08	+.83 +.05	+.75 +.01	+.68 -.02	+.60 -.05	+.53 -.08	+.45 -.11	+.38 -.14

RANGE 32-800 ° F/J (CODE 0016)

Table 4. Calibration Check-Points and Source mV

(Temperature Calibrated) Check-Point (Note 1)	NBS Table mV (Note 2)	COMPENSATED (Temperature Calibrated) Source Output 77°F (25°C) C/J (Note 3)	UNCOMPENSATED (Millivolt Calibrated) Source Output 70°F (21.1°C) C/J (Note 4)
100°F	1.942 mV	0.665 mV	0.866 mV
400°F	11.023 mV	9.746 mV	9.947 mV
750°F	21.785 mV	20.508 mV	20.707 mV

Important: See Notes on page 9

CALIBRATION ERROR CORRECTION TABLE

Table 4-1. Millivolt Correction

SPAN
ZERO

High Reading°F	Low Reading °F										
	95	96	97	98	99	100	101	102	103	104	105
740	-.26 +.14	-.31 +.11	-.36 +.08	-.42 +.05	-.47 +.02	-.52 -.01	-.57 -.04	-.62 -.07	-.68 -.10	-.73 -.13	-.78 -.16
741	-.21 +.14	-.26 +.11	-.31 +.08	-.36 +.05	-.42 +.02	-.47 -.01	-.52 -.04	-.57 -.07	-.62 -.10	-.68 -.13	-.73 -.16
742	-.16 +.14	-.21 +.11	-.26 +.08	-.31 +.05	-.36 +.02	-.42 -.01	-.47 -.04	-.52 -.07	-.57 -.10	-.62 -.13	-.68 -.16
743	-.10 +.14	-.16 +.11	-.21 +.08	-.26 +.05	-.31 +.02	-.36 -.01	-.42 -.04	-.47 -.07	-.52 -.10	-.57 -.13	-.62 -.16
744	-.05 +.14	-.10 +.11	-.16 +.08	-.21 +.05	-.26 +.02	-.31 -.01	-.36 -.04	-.42 -.07	-.47 -.10	-.52 -.13	-.57 -.16
745	.00 +.15	-.05 +.11	-.10 +.08	-.16 +.05	-.21 +.02	-.26 -.01	-.31 -.04	-.36 -.07	-.42 -.10	-.47 -.13	-.52 -.16
746	+.05 +.15	.00 +.12	-.05 +.09	-.10 +.06	-.16 +.03	-.21 .00	-.26 -.03	-.31 -.06	-.36 -.09	-.42 -.12	-.47 -.15
747	+.10 +.15	+.05 +.12	.00 +.09	-.05 +.06	-.10 +.03	-.16 .00	-.21 -.03	-.26 -.06	-.31 -.09	-.36 -.12	-.42 -.15
748	+.16 +.15	+.10 +.12	+.05 +.09	.00 +.06	-.05 +.03	-.10 .00	-.16 -.03	-.21 -.06	-.26 -.09	-.31 -.12	-.36 -.15
749	+.21 +.15	+.16 +.12	+.10 +.09	+.05 +.06	.00 +.03	-.05 .00	-.10 -.03	-.16 -.06	-.21 -.09	-.26 -.12	-.31 -.15
750	+.26 +.15	+.21 +.12	+.16 +.09	+.10 +.06	+.05 +.03	.00 .00	-.05 -.03	-.10 -.06	-.16 -.09	-.21 -.12	-.23 -.15

(Table continued on next page)

RANGE 32-800 °F/J (CODE 0016)

CALIBRATION ERROR CORRECTION TABLE

Table 4-1. Millivolt Correction (Cont.)

SPAN
ZERO

High Reading °F	Low Reading °F										
	95	96	97	98	99	100	101	102	103	104	105
750	+.26 +.15	+.21 +.12	+.16 +.09	+.10 +.06	+.05 +.03	.00 .00	-.05 -.03	-.10 -.06	-.16 -.09	-.21 -.12	-.26 -.15
751	+.31 +.15	+.26 +.12	+.21 +.09	+.16 +.06	+.10 +.03	+.05 .00	.00 -.03	-.05 -.06	-.10 -.09	-.16 -.12	-.21 -.15
752	+.36 +.15	+.31 +.12	+.26 +.09	+.21 +.06	+.16 +.03	+.10 .00	+.05 -.03	.00 -.06	-.05 -.09	-.10 -.12	-.16 -.15
753	+.42 +.15	+.36 +.12	+.31 +.09	+.26 +.06	+.21 +.03	+.16 .00	+.10 -.03	+.05 -.06	.00 -.09	-.05 -.12	-.10 -.15
754	+.47 +.15	+.42 +.11	+.36 +.09	+.31 +.06	+.26 +.03	+.21 .00	+.16 -.03	+.10 -.06	+.05 -.09	.00 -.12	-.05 -.15
755	+.52 +.16	+.47 +.13	+.42 +.10	+.36 +.07	+.31 +.04	+.26 +.01	+.21 -.02	+.16 -.05	+.10 -.08	+.05 -.11	.00 -.15
756	+.57 +.16	+.52 +.13	+.47 +.10	+.42 +.07	+.36 +.04	+.31 +.01	+.26 -.02	+.21 -.05	+.16 -.08	+.10 -.11	+.05 -.14
757	+.62 +.16	+.57 +.13	+.52 +.10	+.47 +.07	+.42 +.04	+.36 +.01	+.31 -.02	+.26 -.05	+.21 -.08	+.16 -.11	+.10 -.14
758	+.68 +.16	+.62 +.13	+.57 +.10	+.52 +.07	+.47 +.04	+.42 +.01	+.36 -.02	+.31 -.05	+.26 -.08	+.21 -.11	+.16 -.14
759	+.73 +.16	+.68 +.13	+.62 +.10	+.57 +.07	+.52 +.04	+.47 +.01	+.42 -.02	+.36 -.05	+.31 -.08	+.26 -.11	+.21 -.14
760	+.78 +.16	+.73 +.13	+.68 +.10	+.62 +.07	+.57 +.04	+.52 +.01	+.47 -.02	+.42 -.05	+.36 -.08	+.31 -.11	+.26 -.14

RANGE 32-999 ° F/J (CODE 0017)

Table 5. Calibration Check-Points and Source mV

(Temperature Calibrated) Check-Point (Note 1)	NBS Table mV (Note 2)	COMPENSATED (Temperature Calibrated) Source Output 77°F (25°C) C/J (Note 3)	UNCOMPENSATED (Millivolt Calibrated) Source Output 70°F (21.1°C) C/J (Note 4)
100°F	1.942 mV	0.665 mV	0.866 mV
500°F	14.108 mV	12.831 mV	13.032 mV
950°F	27.949 mV	26.672 mV	26.873 mV

Important: See Notes on page 9

CALIBRATION ERROR CORRECTION TABLE

Table 5-1. Millivolt Corrections

SPAN
ZERO

High Reading°F	Low Reading °F										
	95	96	97	98	99	100	101	102	103	104	105
940	-.20 +.14	-.24 +.11	-.28 +.08	-.32 +.05	-.36 +.02	-.40 -.01	-.44 -.04	-.48 -.07	-.52 -.10	-.56 -.13	60 -.16
941	-.16 +.14	-.20 +.11	-.24 +.08	-.28 +.05	-.32 +.02	-.36 -.01	-.40 -.04	-.44 -.07	-.48 -.10	-.52 -.13	-.56 16
942	-.12 +.14	-.16 +.11	-.20 +.08	-.24 +.05	-.28 +.02	-.32 -.01	-.36 -.04	-.40 -.07	-.44 -.10	-.48 -.13	-.52 -.16
943	-.08 +.14	-.12 +.11	-.16 +.08	-.20 +.05	-.24 +.02	-.28 -.01	-.32 -.04	-.36 -.06	-.40 -.09	-.44 -.12	-.48 -.15
944	-.04 +.14	-.08 +.11	-.12 +.08	-.16 +.05	-.20 +.03	-.24 .00	-.28 -.03	-.32 -.06	-.36 -.09	-.40 -.12	44 15
945	.00 +.15	-.04 +.12	-.08 +.09	-.12 +.06	-.16 +.03	-.20 .00	-.24 -.03	-.28 -.06	-.32 -.09	-.36 -.12	-.40 -.15
946	+.04 +.15	.00 +.12	-.04 +.09	-.08 +.06	-.12 +.03	-.16 .00	-.20 -.03	-.24 -.06	-.28 -.09	-.32 -.12	-.36 -.15
947	+.08 +.15	+.04 +.12	.00 +.09	-.04 +.06	-.08 +.03	-.12 .00	-.16 -.03	-.20 -.06	-.24 -.09	-.28 -.12	-.32 -.15
948	+.12 +.15	+.08 +.12	+.04 +.09	.00 +.06	-.04 +.03	-.08 .00	-.12 -.03	-.16 -.06	-.20 -.09	-.24 -.12	28 15
949	+.16 +.15	+.12 +.12	+.08 +.09	+.04 +.06	.00 +.03	-.04 .00	-.08 -.03	-.12 -.06	-.16 -.09	-.20 -.12	24 15
950	+.20 +.15	+.16 +.12	+.12 +.09	+.08 +.06	+.04 +.03	.00 .00	-.04 -.03	-.08 -.06	-.12 -.09	-.16 -.12	20 15

(Table continued on next page)

RANGE 32-999 ° F/J (CODE 0017)

CALIBRATION ERROR CORRECTION TABLE

Table 5.1 Millivolt Correction (Cont.)

SPAN
ZERO

High Reading°F	Low Reading °F										
	95	96	97	98	99	100	101	102	103	104	105
950	+.20 +.15	+.16 +.12	+.12 +.09	+.08 +.06	+.04 +.03	.00 .00	-.04 -.03	-.08 -.06	-.12 -.09	-.16 -.12	-.20 -.15
951	+.24 +.15	+.20 +.12	+.16 +.09	+.12 +.06	+.08 +.03	+.04 .00	.00 -.03	-.04 -.06	-.08 -.09	-.12 -.12	-.16 -.15
952	+.28 +.15	+.24 +.12	+.20 +.09	+.16 +.06	+.12 +.03	+.08 .00	+.04 -.03	.00 -.06	-.04 -.09	-.08 -.12	-.12 -.15
953	+.32 +.15	+.28 +.12	+.24 +.09	+.20 +.06	+.16 +.03	+.12 .00	+.08 -.03	+.04 -.06	.00 -.09	-.04 -.12	-.08 -.15
954	+.36 +.15	+.32 +.12	+.28 +.09	+.24 +.06	+.20 +.03	+.16 .00	+.12 -.03	+.08 -.06	+.04 -.09	.00 -.12	-.04 -.15
955	+.40 +.15	+.36 +.12	+.32 +.09	+.28 +.06	+.24 +.03	+.20 .00	+.16 -.03	+.12 -.06	+.08 -.09	+.04 -.12	.00 -.15
956	+.44 +.15	+.40 +.12	+.36 +.09	+.32 +.06	+.28 +.03	+.24 .00	+.20 -.03	+.16 -.05	+.12 -.08	+.08 -.11	+.04 -.14
957	+.48 +.15	+.44 +.12	+.40 +.09	+.36 +.06	+.32 +.04	+.28 +.01	+.24 -.02	+.20 -.05	+.16 -.08	+.12 -.11	+.08 -.14
958	+.52 +.16	+.48 +.13	+.44 +.10	+.40 +.07	+.36 +.04	+.32 +.01	+.28 -.02	+.24 -.05	+.20 -.08	+.16 -.11	+.12 -.14
959	+.56 +.16	+.52 +.13	+.48 +.10	+.44 +.07	+.40 +.04	+.36 +.01	+.32 -.02	+.28 -.05	+.24 -.08	+.20 -.11	+.16 -.14
960	+.60 +.16	+.56 +.13	+.52 +.10	+.48 +.07	+.44 +.04	+.40 +.01	+.36 -.02	+.32 -.05	+.28 -.08	+.24 -.11	+.20 -.14

RANGE 0-400 ° C/J (CODE 0022)

Table 6. Calibration Check-Points and Source mV

(Temperature Calibrated) Check-Point (Note 1)	NBS Table mV (Note 2)	COMPENSATED (Temperature Calibrated) Source Output 77°F (25°C) C/J (Note 3)	UNCOMPENSATED (Millivolt Calibrated) Source Output 70°F (21.1°C) C/J (Note 4)
50°F	2.585 mV	1.308 mV	1.515 mV
200°F	10.777 mV	9.500 mV	9.707 mV
350°F	19.089 mV	17.812 mV	18.019 mV

Important: See Notes on page 9.

CALIBRATION ERROR CORRECTION TABLE

Table 6-1. Millivolt Correction

SPAN
ZERO

High Reading°C	Low Reading °C										
	45	46	47	48	49	50	51	52	53	54	55
340	-.56 +.24	-.68 +.18	-.79 +.13	-0.90 +0.07	-1.01 +0.01	-1.13 -0.04	-1.24 -0.10	-1.35 -0.16	-1.46 -0.21	-1.58 -0.27	-1.69 -0.33
341	-.45 +.24	-.56 +.19	-.68 +.13	-0.79 +0.07	-0.90 +0.02	-1.01 -0.04	-1.13 -0.10	-1.24 -0.15	-1.35 -0.21	-1.46 -0.26	-1.58 -0.32
342	-.34 -.25	-.45 +.19	-.56 +.13	-0.68 +0.08	-0.79 +0.02	-0.90 -0.03	-1.01 -0.09	-1.13 -0.15	-1.24 -0.20	-1.35 -0.26	-1.46 -0.32
343	-.23 -.25	-.34 +.20	-.45 +.14	-0.56 +0.08	-0.68 +0.03	-0.79 -0.03	-0.90 -0.09	-1.01 -0.14	-1.13 -0.20	-1.24 -0.26	-1.35 -0.31
344	-.11 +.26	-.23 +.20	-.34 +.14	-0.45 +0.09	-0.56 -0.03	-0.68 -0.03	-0.79 -0.08	-0.90 -0.14	-1.01 -0.20	-1.13 -0.25	-1.24 -0.31
345	.00 +.26	-.11 +.20	-.23 +.15	-0.34 +0.09	-0.45 -0.03	-0.56 -0.02	-0.68 -0.08	-0.79 -0.13	-0.90 -0.19	-1.01 -0.25	-1.13 -0.30
346	+.11 +.26	.00 +.21	-.11 +.15	-0.23 +0.10	-0.34 +0.04	-0.45 -0.02	-0.56 -0.07	-0.68 -0.13	-0.79 -0.19	-0.90 -0.24	-1.01 -0.30
347	+.23 +.27	+.11 +.21	.00 +.16	-0.11 +0.10	-0.23 -0.04	-0.34 -0.01	-0.45 -0.07	-0.56 -0.13	-0.68 -0.18	-0.79 -0.24	-0.90 -0.29
348	+.34 +.27	+.23 +.22	+.11 +.16	0.00 +0.10	-0.11 +0.05	-0.23 -0.01	-0.34 -0.07	-0.45 -0.12	-0.56 -0.18	-0.68 -0.23	-0.79 -0.29
349	+.45 +.28	+.34 +.22	+.23 +.16	+0.11 +0.11	0.00 +0.05	-0.11 0.00	-0.23 -0.06	-0.34 -0.12	-0.45 -0.17	-0.56 -0.23	-0.68 -0.29
350	+.56 +.28	+.45 +.23	+.34 +.17	+0.23 +0.11	+0.11 +0.06	0.00 0.00	-0.11 -0.06	-0.23 -0.11	-0.34 -0.17	-0.45 -0.23	-0.56 -0.28

(Table continued on next page)

RANGE 0-400 °C/J (CODE 0022)

CALIBRATION ERROR CORRECTION TABLE

Table 6-1. Millivolt Correction (Cont.)

SPAN
ZERO

High Reading °C	Low Reading °C										
	45	46	47	48	49	50	51	52	53	54	55
350	+0.56 +0.28	+0.45 +0.23	+0.34 +0.17	+0.23 +0.11	+0.11 +0.06	0.00 0.00	-0.11 -0.06	-0.23 -0.11	-0.34 -0.17	-0.45 -0.23	-0.56 -0.28
351	+0.68 +0.29	+0.56 +0.23	+0.45 +0.17	+0.34 +0.12	+0.23 +0.06	+0.11 0.00	0.00 -0.05	-0.11 -0.11	-0.23 -0.16	-0.34 -0.22	-0.45 -0.28
352	+0.79 +0.29	+0.68 +0.23	+0.56 +0.18	+0.45 +0.12	+0.34 +0.07	+0.23 +0.01	+0.11 -0.05	0.00 -0.10	-0.11 -0.16	-0.23 -0.22	-0.34 -0.27
353	+0.90 +0.29	+0.79 +0.24	+0.68 +0.18	+0.56 +0.13	+0.45 +0.07	+0.34 +0.01	+0.23 -0.04	+0.11 -0.10	0.00 -0.16	-0.11 -0.21	-0.23 -0.27
354	+1.01 +0.30	+0.90 +0.24	+0.79 +0.19	+0.68 +0.13	+0.56 +0.07	+0.45 +0.02	+0.34 -0.04	+0.23 -0.10	+0.11 -0.15	0.00 -0.21	-0.11 -0.26
355	+1.13 +0.30	+1.01 +0.25	+0.90 +0.19	+0.79 +0.13	+0.68 +0.08	+0.56 +0.02	+0.45 -0.03	+0.34 -0.09	+0.23 -0.15	+0.11 -0.20	0.00 -0.26
356	+1.24 +0.31	+1.13 +0.25	+1.01 +0.20	+0.90 +0.14	+0.79 +0.08	+0.68 +0.03	+0.56 -0.03	+0.45 -0.09	+0.34 -0.14	+0.23 -0.20	+0.11 -0.26
357	+1.35 +0.31	+1.24 +0.26	+1.13 +0.20	+1.01 +0.14	+0.90 +0.09	+0.79 +0.03	+0.68 -0.03	+0.56 -0.08	+0.45 -0.14	+0.34 -0.20	+0.23 -0.25
358	+1.46 +0.32	+1.35 +0.26	+1.24 +0.20	+1.13 +0.15	+1.01 +0.09	+0.90 +0.03	+0.79 -0.02	+0.68 -0.08	+0.56 -0.13	+0.45 -0.19	+0.34 -0.25
359	+1.58 +0.32	+1.46 +0.26	+1.35 +0.21	+1.24 +0.15	+1.13 +0.10	+1.01 +0.04	+0.90 -0.02	+0.79 -0.07	+0.68 -0.13	+0.56 -0.19	+0.45 -0.24
360	+1.69 +0.33	+1.58 +0.27	+1.46 +0.21	+1.35 +0.16	+1.24 +0.10	+1.13 +0.04	+1.01 -0.01	+0.90 -0.07	+0.79 -0.13	+0.68 -0.18	+0.56 -0.24

RANGE 0-600 ° C/J (CODE 0024)

Table 7. Calibration Check-Points and Source mV

(Temperature Calibrated) Check-Point (Note 1)	NBS Table mV (Note 2)	COMPENSATED (Temperature Calibrated) Source Output 77°F (25°C) C/J (Note 3)	UNCOMPENSATED (Millivolt Calibrated) Source Output 70°F (21.1°C) C/J (Note 4)
50°C	2.585 mV	1.308 mV	1.515 mV
300°C	16.325 mV	15.048 mV	15.255 mV
550°C	30.210 mV	28.933 mV	29.140 mV

Important: See Notes on page 9.

CALIBRATION ERROR CORRECTION TABLE

Table 7-1. Millivolt Correction

SPAN
ZERO

High Reading°C	Low Reading °C										
	45	46	47	48	49	50	51	52	53	54	55
540	-.34 +.25	-.41 +.19	-.47 +.14	-.54 +.08	-.61 +.03	-.68 -.03	-.74 -.08	-.81 -.14	-.88 -.19	-.95 -.24	-1.01 -0.30
541	-.27 +.25	-.34 +.20	-.41 +.14	-.47 +.09	-.54 +.03	-.61 -.02	-.68 -.08	-.74 -.13	-.81 -.19	-.88 -.24	-0.95 -0.30
542	-.20 +.25	-.27 +.20	-.34 +.14	-.41 +.09	-.47 +.03	-.54 -.02	-.61 -.08	-.68 -.13	-.74 -.18	-.81 -.24	-0.88 -0.29
543	-.14 +.25	-.20 +.20	-.27 +.15	-.34 +.09	-.41 +.04	-.47 -.02	-.54 -.07	-.61 -.13	-.68 -.18	-.74 -.24	-0.81 -0.29
544	-.07 +.26	-.14 +.20	-.20 +.15	-.27 +.09	-.34 +.04	-.41 -.02	-.47 -.07	-.54 -.12	-.61 -.18	-.68 -.23	-0.74 -0.29
545	.00 +.26	-.07 +.21	-.14 +.15	-.20 +.10	-.27 +.04	-.34 -.01	-.41 -.07	-.47 -.12	-.54 -.18	-.61 -.23	-0.68 -0.29
546	+.07 +.26	.00 +.21	-.07 +.15	-.14 +.10	-.20 +.04	-.27 -.01	-.34 -.07	-.41 -.12	-.47 -.17	-.54 -.23	-0.61 -0.28
547	+.14 +.27	+.07 +.21	.00 +.16	-.07 +.10	-.14 +.05	-.20 -.01	-.27 -.06	-.34 -.12	-.41 -.17	-.47 -.23	-0.54 -0.28
548	+.20 +.27	+.14 +.21	+.07 +.16	.00 +.10	-.07 +.05	-.14 -.01	-.20 -.06	-.27 -.11	-.34 -.17	-.41 -.22	-0.47 -0.28
549	+.27 +.27	+.20 +.22	+.14 +.16	+.07 +.11	.00 +.05	-.07 .00	-.14 -.06	-.20 -.11	-.27 -.17	-.34 -.22	-0.41 -0.28
550	+.34 +.27	+.27 +.22	+.20 +.16	+.14 +.11	+.07 +.05	.00 .00	-.07 -.05	-.14 -.11	-.20 -.16	-.27 -.22	-0.34 -0.27

(Table continued on next page)

RANGE 0-600 ° C/J (CODE 0024)

CALIBRATION ERROR CORRECTION TABLE

Table 7-1. Millivolt Correction (Cont.)

SPAN
ZERO

High Reading °C	Low Reading °C										
	45	46	47	48	49	50	51	52	53	54	55
550	+ .34 + .27	-.27 +.22	+.20 +.16	-.14 +.11	+.07 +.05	.00 .00	-.07 -.05	-.14 -.11	-.20 -.16	-.27 -.22	-.34 -.27
551	+ .41 + .28	+.34 +.22	+.27 +.17	+.20 +.11	+.14 +.06	+.07 .00	.00 -.05	-.07 -.11	-.14 -.16	-.20 -.22	-.27 -.27
552	+ .47 + .28	+.41 +.22	+.34 +.17	+.27 +.11	+.20 +.06	+.14 +.01	+.07 -.05	.00 -.10	-.07 -.16	-.14 -.21	-.20 -.27
553	+ .54 + .28	+.47 +.23	+.41 +.17	+.34 +.12	+.27 +.06	+.20 +.01	+.14 -.05	+.07 -.10	.00 -.16	-.07 -.21	-.14 -.27
554	+ .61 + .28	+.54 +.23	+.47 +.17	+.41 +.12	+.34 +.07	+.27 +.01	+.20 -.04	+.14 -.10	+.07 -.15	.00 -.21	-.07 -.26
555	+ .68 + .29	+.61 +.23	+.54 +.18	+.47 +.12	+.41 +.07	+.34 +.01	+.27 -.04	+.20 -.10	+.14 -.15	+.07 -.21	.00 -.26
556	+ .74 + .29	+.68 +.23	+.61 +.18	+.54 +.12	+.47 +.07	+.41 +.02	+.34 -.04	+.27 -.09	+.20 -.15	+.14 -.20	+.07 -.26
557	+ .81 + .29	+.74 +.24	+.68 +.18	+.61 +.13	+.54 +.07	+.47 +.02	+.41 -.04	+.34 -.09	+.27 -.15	+.20 -.20	+.14 -.25
558	+ .88 + .29	+.81 +.24	+.74 +.18	+.68 +.13	+.61 +.08	+.54 +.02	+.47 -.03	+.41 -.09	+.34 -.14	+.27 -.20	+.20 -.25
559	+ .95 + .30	+.88 +.24	+.81 +.19	+.74 +.13	+.68 +.08	+.61 +.02	+.54 -.03	+.47 -.09	+.41 -.14	+.34 -.20	+.27 -.25
560	+1.01 +0.30	+.95 +.24	+.88 +.19	+.81 +.14	+.74 +.08	+.68 +.03	+.61 -.03	+.54 -.08	+.47 -.14	+.41 -.19	+.34 -.25

RANGE 32-400 ° F/J (CODE 0056)

Table 8. Calibration Check-Points and Source mV

(Temperature Calibrated) Check-Point (Note 1)	NBS Table mV (Note 2)	COMPENSATED (Temperature Calibrated) Source Output 77°F (25°C) C/J (Note 3)	UNCOMPENSATED (Millivolt Calibrated) Source Output 70°F (21.1°C) C/J (Note 4)
100°F	1.942 mV	0.665 mV	0.866 mV
200°F	4.906 mV	3.629 mV	3.830 mV
350°F	9.483 mV	8.206 mV	8.407 mV

Important: See Notes on page 9.

CALIBRATION ERROR CORRECTION TABLE

Table 8-1. Millivolt Correction

SPAN
ZERO

High Reading °C	Low Reading °F										
	95	96	97	98	99	100	101	102	103	104	105
340	-0.68 +0.13	-0.81 +0.10	-0.95 +0.07	-1.08 +0.04	-1.22 +0.01	-1.35 -0.03	-1.49 -0.06	-1.62 -0.09	-1.76 -0.12	-1.89 -0.15	-2.03 -0.18
341	-0.54 +0.13	-0.68 +0.10	-0.81 +0.07	-0.95 +0.04	-1.08 +0.01	-1.22 -0.02	-1.35 -0.06	-1.49 -0.09	-1.62 -0.12	-1.76 -0.15	-1.89 -0.18
342	-0.41 +0.14	-0.54 +0.11	-0.68 +0.07	-0.81 +0.04	-0.95 +0.01	-1.08 -0.02	-1.22 -0.05	-1.35 -0.08	-1.49 -0.12	-1.62 -0.15	-1.76 -0.18
343	-0.27 +0.14	-0.41 +0.11	-0.54 +0.08	-0.68 +0.04	-0.81 +0.01	-0.95 -0.02	-1.08 -0.05	-1.22 -0.08	-1.35 -0.11	-1.49 -0.15	-1.62 -0.18
344	-0.14 +0.14	-0.27 +0.11	-0.41 +0.08	-0.54 +0.05	-0.68 +0.02	-0.81 -0.02	-0.95 -0.05	-1.08 -0.08	-1.22 -0.11	-1.35 -0.14	-1.49 -0.17
345	0.00 +0.15	-0.14 +0.11	-0.27 +0.08	-0.41 +0.05	-0.54 +0.02	-0.68 -0.01	-0.81 -0.04	-0.95 -0.08	-1.08 -0.11	-1.22 -0.14	-1.35 -0.17
346	+0.14 +0.15	0.00 +0.12	-0.14 +0.08	-0.27 +0.05	-0.41 +0.02	-0.54 -0.01	-0.68 -0.04	-0.81 -0.07	-0.95 -0.11	-1.08 -0.14	-1.22 -0.17
347	+0.27 +0.15	+0.14 +0.12	0.00 +0.09	-0.14 +0.06	-0.27 +0.02	-0.41 -0.01	-0.54 -0.04	-0.68 -0.07	-0.81 -0.10	-0.95 -0.13	-1.08 -0.17
348	+0.41 +0.15	+0.27 +0.12	+0.14 +0.09	0.00 +0.06	-0.14 +0.03	-0.27 -0.01	-0.41 -0.04	-0.54 -0.07	-0.68 -0.10	-0.81 -0.13	-0.95 -0.16
349	+0.54 +0.16	+0.41 +0.12	+0.27 +0.09	+0.14 +0.06	0.00 +0.03	-0.14 0.00	-0.27 -0.03	-0.41 -0.07	-0.54 -0.10	-0.68 -0.13	-0.81 -0.16
350	+0.68 +0.16	+0.54 +0.13	+0.41 +0.09	+0.27 +0.06	+.0.14 +0.03	0.00 0.00	-0.14 -0.03	-0.27 -0.06	-0.41 -0.09	-0.54 -0.13	-0.68 -0.16

(Table continued on next page)

RANGE 32-400 °F/J (CODE 0056)

CALIBRATION ERROR CORRECTION TABLE

Table 8-1. Millivolt Correction (Cont.)

SPAN
ZERO

High Reading °C	Low Reading °F										
	95	96	97	98	99	100	101	102	103	104	105
350	+0.68 +0.16	+0.54 +0.13	+0.41 +0.09	+0.27 +0.06	+0.14 +0.03	0.00 0.00	-0.14 -0.03	-0.27 -0.06	-0.41 -0.09	-0.54 -0.13	-0.68 -0.16
351	+0.81 +0.16	+0.68 +0.13	+0.54 +0.10	+0.41 +0.07	+0.27 +0.03	+0.14 0.00	0.00 -0.03	-0.14 -0.06	-0.27 -0.09	-0.41 -0.12	-0.54 -0.16
352	+0.95 +0.16	+0.81 +0.13	+0.68 +0.10	+0.54 +0.07	+0.41 +0.04	+0.27 +0.01	+0.14 -0.03	0.00 -0.06	-0.14 -0.09	-0.27 -0.12	-0.41 -0.15
353	+1.08 +0.17	+0.95 +0.13	+0.81 +0.10	+0.68 +0.07	+0.54 +0.04	+0.41 +0.01	+0.27 -0.02	+0.14 -0.06	0.00 -0.09	-0.14 -0.12	-0.27 -0.15
354	+1.22 +0.17	+1.08 +0.14	+0.95 +0.11	+0.81 +0.07	+0.68 +0.04	+0.54 +0.01	+0.41 -0.02	+0.27 -0.05	+0.14 -0.08	0.00 -0.12	-0.14 -0.15
355	+1.35 +0.17	+1.22 +0.14	+1.08 +0.11	+0.95 +0.08	+0.81 +0.04	+0.68 +0.01	+0.54 -0.02	+0.41 -0.05	+0.27 -0.08	+0.14 -0.11	0.00 -0.15
356	+1.49 +0.17	+1.35 +0.14	+1.22 +0.11	+1.08 +0.08	+0.95 +0.05	+0.81 +0.02	+0.68 -0.02	+0.54 -0.05	+0.41 -0.08	+0.27 -0.11	+0.14 -0.14
357	+1.62 +0.18	+1.49 +0.15	+1.35 +0.11	+1.22 +0.08	+1.08 +0.05	+0.95 +0.02	+0.81 -0.01	+0.68 -0.04	+0.54 -0.08	+0.41 -0.11	+0.27 -0.14
358	+1.76 +0.18	+1.62 +0.15	+1.49 +0.12	+1.35 +0.08	+1.22 +0.05	+1.08 +0.02	+0.95 -0.01	+0.81 -0.04	+0.68 -0.07	+0.54 -0.11	+0.41 -0.14
359	+1.89 +0.18	+1.76 +0.15	+1.62 +0.12	+1.49 +0.09	+1.35 +0.06	+1.22 +0.02	+1.08 -0.01	+0.95 -0.04	+0.81 -0.07	+0.68 -0.10	+0.54 -0.13
360	+2.03 +0.18	+1.89 +0.15	+1.76 +0.12	+1.62 +0.09	+1.49 +0.06	+1.35 +0.03	+1.22 -0.01	+1.08 -0.04	+0.95 -0.07	+0.81 -0.10	+0.68 -0.13

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